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# Analysis and Recommendations for the GUI Integration of COTS Software with ECS

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## Preface

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This report was originally prepared in September 1995. Initial internal reviews during late 1995 and early 1996 identified several areas for revision and improvement, some of them related to ongoing changes in the design of ECS. For example, at the time the reported analysis was being conducted, the Planning Subsystem design included use of *AutoSys* in resource planning, but subsequently the design changed to rely on another product, *Delphi*, for that application. Furthermore, many of the commercial, off-the-shelf (COTS) products reviewed for the analysis were reviewed in a "raw" state just as they were freshly installed and before any planned customization for ECS use. Thus, some of the concerns raised in the initial report may have been affected by system changes that have occurred since the analysis. This revision of the report incorporates some additions, corrections, and revisions based on initial internal reviews, including those by Release A and Release B developers, and on system changes. The basic content of the report, however, remains largely unchanged, with the following exceptions. A section has been added presenting the combined responses of the Release A, Release B, and M&O reviewers. Another added section presents the results of an examination of one additional COTS product suggested by the reviewers. The conclusions and recommendations of the report should be viewed in light of the current system design and status.

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# Abstract

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The operator/user interfaces for the Earth Observing System Data Information System (EOSDIS) Core System (ECS) include interfaces for Commercial Off-the-Shelf (COTS) and other off-the-shelf (OTS) products as well as graphical user interfaces (GUIs) developed specifically for ECS subsystems. An examination of the likely patterns of developmental and COTS software use reveals that several ECS operators/users may be expected to interact with a range of GUIs. Differences in the 'look and feel' of the GUIs can result in an increased potential for operator/user performance errors, or at least reduce operator productivity in operating and using ECS subsystems. Adherence to the *ECS User Interface Style Guide* in the development of GUIs for ECS subsystems fosters a consistent look and feel in ECS interfaces. However, a review of some of the major COTS products to be integrated into the ECS reveals wide variation in the degree of compliance with the guidelines in the *ECS User Interface Style Guide*, and a significant range in the degree to which these products can be made to comply with the guidelines. It is recommended that whatever features and capabilities are provided in the COTS software products to accommodate user preferences and other adjustments in the look and feel of the GUIs be exploited to make them conform insofar as possible to the guidelines.

**Keywords:** Graphical User Interface, User Interface Style Guide, COTS Integration, ECS Software

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# Executive Summary

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A three step analysis was conducted to establish the effective integration of Commercial-Off-The-Shelf (COTS) Graphical User Interfaces (GUIs) into ECS. The first step was to identify the ECS operator and user roles and job functions and the suite of ECS software with which each will interact. The results of this analysis were incorporated into a matrix. This matrix was used to select a small set of COTS products in order to perform a series of human factors assessments (step two) of the GUIs provided with each product. The results of these assessments were documented in tables containing a list of human engineering comments. The final step was to derive a series of recommended interventions for achieving the cost-effective integration of COTS GUIs with ECS. The Release A, Release B, and Maintenance and Operations (M&O) response to each of these recommendations is enclosed in this report.

In general, the implementation of the HMI methodology and compliance with the ECS User Interface Style Guide, to the extent it is practical and useful, is recommended as the best means to achieve an effective integration of COTS GUIs with the suite of software to be used in ECS releases. Specific recommended interventions designed to resolve identified human factors problems are shown in Table ES-1.

The first four recommendations (two that recommend workflow analysis and two that recommend an engineering analysis to assess the likelihood and severity of failures) are specific to concerns raised during the human factors assessment of the GUIs for the AutoSys/Xpert and the HP OpenView products. The following set of four recommendations (two that recommend personnel selection policies and two that recommend training development in fault management) are interventions designed to address shortcomings in the proposed COTS products (AutoSys/Xpert and HP OpenView) with respect to the support provided to operators in responding to common cause or common mode failures. Their implementation is dependent upon the outcome of the preceding four analysis recommendations. To the extent that these concerns are genuine (as reflected in an engineering analysis that identifies the frequency and severity of such failures), it may or may not be cost-effective to implement these interventions.

Additional interpretations and findings are contained in the body of this report.

**Table ES-1. Recommended Interventions for  
Ensuring the Effective Integration of COTS GUIs**

Type of Intervention	Applicable Product	Recommendation
Workflow Analysis	AutoSys/Xpert	Conduct detailed workflow analysis of realistic and relevant data processing fault management scenarios designed to address the monitoring, detection, identification, and resolution of common cause and common mode failures
	HP OpenView	Conduct detailed workflow analysis of realistic and relevant system and network fault management scenarios designed to address the monitoring, detection, identification, and resolution of common cause and common mode failures
Analysis of the Severity and Frequency of Common Cause and Common Mode Failures	AutoSys/Xpert	Conduct an analysis to determine the extent to which data processing faults occur due to a common cause or common mode failure, as a basis for assessing the cost-benefit associated with personnel selection and training interventions that follow
	HP OpenView	Conduct an analysis to determine the extent to which system and network faults occur due to a common cause or common mode failure, as a basis for assessing the cost-benefit associated with personnel selection and training interventions that follow
Personnel Selection/Job Definition	AutoSys/Xpert	Recommend the development and adoption of personnel selection/job definition policies that require demonstrated fault management aptitude (per section 4.2, Establishment of Certification Requirements, contained in the Training Plan for the ECS Project, 622-CD-001-001)
Personnel Selection/Job Definition (continued)	HP OpenView	Recommend the development and adoption of personnel selection/job definition policies that require demonstrated fault management aptitude (per section 4.2, Establishment of Certification Requirements, contained in the Training Plan for the ECS Project, 622-CD-001-001)
Training and Job Aid Development	AutoSys/Xpert	Develop fault management training and exercises designed to instruct operators on fault management operations associated with data processing failures/errors (especially for common cause and common mode failures) (per section 4.2, Establishment of Certification Requirements, contained in the Training Plan for the ECS Project, 622-CD-001-001)
	HP OpenView	Develop fault management training and exercises and job aids designed to instruct operators on fault management operations associated with system and network failures/errors (especially for common cause and common mode failures) (per section 4.2, Establishment of Certification Requirements, contained in the Training Plan for the ECS Project, 622-CD-001-001)
Tailor COTS GUIs	AutoSys/Xpert (per section 3.2) HP OpenView (per section 3.3) Remedy (per section 3.4) Z-Mail (per section 3.6)  All COTS (per section 3.7)	Tailor the x-app defaults and user preferences of each COTS product to comply with the human factors guidelines contained in the ECS User Interface Style Guide to minimize operator/user performance errors and maximize productivity
Leverage vendor modifications to COTS GUIs	AutoSys/Xpert (per section 3.2)	Leverage ECS status as largest customer for AutoSys to encourage Platinum Technology to resolve GUI problems identified in Table 3.2-1
Encapsulate COTS product with custom GUI(s)	Sybase	Develop custom-coded GUIs for all ECS subsystems that require access to the Sybase database engine. Native Sybase GUIs are non-compliant with the Motif standards and the ECS User Interface Style Guide.

# 1. Introduction

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The design of the Earth Observing System Data Integration System (EOSDIS) Core System (ECS) incorporates a number of commercial off-the-shelf (COTS) or other off-the-shelf (OTS) software products as well as custom-developed software. The *ECS User Interface Style Guide* provides guidance for the development of graphical user interfaces (GUIs) with a consistent 'look and feel' for ECS software. However, the incorporation of COTS/OTS products raises the concern that variation in styles of ECS GUIs may lead to increased probability of operator/user performance error, or at the very least become a source of reduced productivity, in system operation and use. This potential is further compounded by the presence of HyperText Mark-Up Language (HTML) in ECS applications. The challenge facing ECS developers is to design and tailor custom-developed, COTS/OTS, and HTML GUIs to produce an effective integration of ECS software.

To address this challenge, the study reported here initiated a three-step analysis to address the integration of ECS software GUIs. The first step was to identify the variety of interfaces likely to be encountered by operators/users of ECS applications. The second step was to assess the human factors aspects of COTS GUIs, with a focus on operator/user roles likely to face significant variation in GUI environments/styles. The final step is to identify cost-effective interventions that can have the maximum effect to reduce the impact of that variation.

## 1.1 Scope

The three-step effort reported here provides a basis for interventions to facilitate the integration of COTS software products into ECS and achieve a common look and feel across ECS interfaces and thereby help improve the overall usability and acceptability of the system. The first step is an analysis to determine what software products, including COTS/OTS, custom Motif-based, and custom HTML-based applications, will be used in various job functions in the range of ECS operations, maintenance, and use. This analysis enables identification of job functions that may be affected by potential differences between products in the GUI paradigms/metaphors used.

The second step is a human factors assessment of the usability of selected COTS products identified in the first step as applications used in large numbers of ECS job functions. The focus of the assessment is on the product GUIs, to determine the degree to which they comply, or can be cost-effectively made to comply, with the *ECS User Interface Style Guide* and NASA requirements. The COTS products initially reviewed for this assessment included: *Autosys/Xpert*, *HP OpenView*, *Remedy*, *SYBASE*, and *Z-Mail*. A sixth COTS product, *Tivoli*, was examined in response to review comments.

The third step is recommendations for interventions to reduce the likelihood of performance errors or decreased productivity induced by the variety of GUI environments with which operators/users must contend. For example, we tailor those COTS/OTS products found to deviate

from the style specified in the *ECS User Interface Style Guide* to bring them as nearly as possible into compliance. The interventions are recommended in view of cost considerations, and thus include primarily tailoring them through use of their internal capabilities for adjustment (e.g., user preference settings), training, or other response to the human engineering comments identified in the second step of the effort.

## 1.2 Applicable Documents

The following documents are referenced herein and are directly applicable to this analysis.

607-CD-001-002	Maintenance and Operations Manual for the ECS Project
622-CD-001-002	Training Plan for the ECS Project
410-TD-001-003	ECS User Interface Style Guide for the ECS Project
DSTL-92-007	National Aeronautics and Space Administration, Human-Computer Interface Guidelines, August 1992
801-5366-10	Sun Corporation, Motif 1.2 Style Guide, July 1993
ESD-TR-86-278	Smith, S.L & Mosier, J.N. Guidelines for Designing User Interface Software, Electronic Systems Division, AFSC, August 1986
J2311-90002	Hewlett Packard, HP OpenView Windows User's Guide, December 1993
J2319-90002	Hewlett Packard, HP OpenView Windows Programmer's Guide, December 1993
J2310-90002	Hewlett Packard, HP OpenView Windows Application Design and Style Guide, December 1993
none	AutoSystems Corporation, AutoSys User Manual - v3.1, September, 1994
none	PLATINUM AutoSys Xpert User Guide BETA 1.0. July, 1994
none	PLATINUM AutoSys User Guide; Revised/Added Sections BETA Version 3.2
AMX-200-DA2-001	Remedy Corporation, Action Request System 2.0 Administrator's Guide for OSF/Motif, January 1995
AMX-200-DA2-001	Remedy Corporation, Action Request System 2.0 User's Guide for OSF/Motif, January 1995

## 1.3 Document Organization

The contents of this report are as follows:

### Executive Summary

- Chapter 1 Introduction -- Introduces the Human Machine Interface (HMI) assessment of COTS for the purpose of integration into ECS. Discusses scope, purpose, objectives, applicable documentation and document organization.
- Chapter 2 Discusses the methodology employed in the HMI assessment of COTS products.
- Chapter 3 Discusses results of HMI assessment of COTS products.
- Chapter 4 Defines recommendations to integrate COTS applications into ECS, customizing them to the extent possible and practicable for compliance with the *ECS User Interface Style Guide*.
- Chapter 5 Presents review comments on an earlier draft of this report, and includes additional analysis in response to the comments.
- Appendix A ECS Operator Positions and Responsibilities (from 607-CD-001-002) and User Characterization
- Appendix B ECS Software Product/Function Description

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## 2. Methodology

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The analysis and recommendations effort consisted of three steps: 1) development of a matrix to identify the graphical user interface (GUI) environments likely to be encountered by ECS operators/users in their various roles or job functions; 2) assessment of the human-machine interface (HMI) characteristics of major COTS software products planned for use in ECS and identification of human engineering comments concerning notable features or characteristics of the products likely to lead to increased operator/user performance error and/or reduced productivity; and 3) preparation of recommendations for interventions that can address the major comments within cost-effectiveness constraints. The approach for each step is addressed separately in one of the following subsections.

### 2.1 Matrix Identifying GUI Environments by Operators/Users

The first step was development of a matrix to list operator/user roles and to identify the GUI environments used by the many COTS/OTS software and other applications with which the operators/users will interact. The majority of operator/user roles in the matrix were extracted from a list provided in *Maintenance and Operations Manual for the ECS Project*, Document 607-CD-001-002. Three additional 'roles' were added to include more users in a broadened representation of operators/users; two of these were user roles selected from an earlier working paper, *ECS User Characterization Methodology and Results*, Document 194-00313TPW. The last role was NASA Management, added to reflect their participation in oversight of the program. Appendix A provides a table of operator positions and responsibilities taken from 607-CD-001-002, and a table with a brief characterization of ECS users.

Appendix B provides a table listing the software products or functions that have associated GUI environments for the operators/users. The software products or applications were grouped into COTS/OTS, custom Motif-based, and custom HTML-based applications and arrayed along one axis of the matrix, with the operators/users or ECS job functions arrayed along the other axis. ECS Subsystem developers were asked to mark the matrix to identify COTS/OTS and other GUI environments with which these operators/users were likely to interact.

The matrix was designed to permit identification of those GUI environments likely to have an impact on a large number of ECS job functions. By extension, the matrix was also designed to identify GUI environments which serve the same job functions, and thereby present potential for conflict if they are inconsistent in look and feel. That is, these two criteria, taken together, were used to identify GUI environments that may present paradigms or metaphors incompatible with the *ECS User Interface Style Guide* and with each other, and that affect a significant number of ECS job functions. This provided a basis for selecting specific COTS products for further examination and assessment and for recommendation of interventions with maximum potential impact to achieve a common look and feel for ECS operator/user interfaces.

## 2.2 Human Factors Evaluation of the Human Machine Interface

For the second step of the effort, a Human Factors Evaluation was conducted on several COTS products. The purpose of this evaluation was to critique the Human Machine Interface in terms of user operability and compliance with the *ECS User Interface Style Guide*. Evaluation focused on the GUI. It was assumed that the products adequately provide the necessary functionality to perform the tasks for which they were selected. The evaluation was not intended to assess the functionality and/or utility of the applications themselves in their planned roles in ECS operations. The evaluation was conducted to identify discrepancies and inconsistencies between the ECS GUI style as reflected in the *ECS USER Interface Style guide* and the COTS GUI style. It was intended that the results of this assessment be used in the cost-effective integration of COTS applications into the ECS system and that these COTS have a similar look and feel to custom developed ECS GUIs to the maximum extent practicable.

Five COTS products were initially evaluated; these products include *Autosys/Xpert*, *HP Openview*, *Remedy*, *SYBASE*, and *Z-Mail*. A sixth product, *Tivoli*, was reviewed in response to internal review comments. Human factors evaluators examined available product documentation such as user/operator manuals. The purpose was to gain insight into how the product functioned. Following document review, the COTS software was brought on line and reviewed. Most of the applications were examined and manipulated directly by the evaluators. For *Autosys/Xpert*, however, an interactive demonstration was given by Data Processing Subsystem developers familiar with the application. During and following on-line familiarization, each evaluator completed a *COTS Software Human Factors Evaluation Preview Worksheet*.

The COTS Software Human Factors Evaluation Preview Worksheet was designed to assess COTS on a number of factors that relate to style and usability according to *ECS User Interface Style Guide*, NASA requirements, and basic Human Factors GUI design principles. The evaluations included areas such as general HMI considerations, data entry, data display, interactive control, feedback, prompts, defaults, error management/ data protection, system response time, and data/message transmission. Each of these aspects of a given interface were assessed (when appropriate) against criteria that included consistency, compatibility with operator skill/operation, flexibility, simplicity, and information load. The worksheet data for each COTS product were consolidated into a table of human engineering comments to identify major problem areas, sources of guidelines against which potential style problems were cited, the criticality and status of each problem, and proposed resolutions to each problem whenever possible and appropriate. Each product was also specifically assessed concerning its potential reconfigurability for compliance with the *ECS User Interface Style Guide*, with particular focus on internal capabilities for adapting its GUI and/or easily adjusting its look and feel (e.g., through flexible manipulation of user preferences). Finally, for each product GUI, an assessment was made of its cross-product compatibility with other ECS GUIs, taking into account the clustering of GUIs by operator/user/job function.

### 2.2.1 Human Engineering Comments List Columns and Criteria for COTS/OTS Software

The Human Engineering Comments list is prepared as the outcome of a human factors assessment of COTS/OTS software. The list consists of four columns as identified below.

**Human Engineering Comment** - This column provides a concise description of the human factors problem identified. Specific examples may be included to illustrate the specific software functionality involved with the problem.

**Criticality** - This column gives a three-level assessment of the impact of a Human Engineering Comment on the likelihood of human error, reduced productivity, or efficiency. The three levels of criticality are:

*Critical* - A Human Engineering Comment is critical if it involves a high likelihood of human error and/or could result in substantial reductions in operator/user productivity.

*Important* - A Human Engineering Comment is important if there is a moderate likelihood of human error and/or could result in substantial reductions in operator/user productivity.

*Advisory Notice* - A Human Engineering Comment is assessed an Advisory Notice when the software functionality does not comply with human factors guidelines contained in the *ECS User Interface Style Guide*. Impacts on human error or productivity are considered negligible otherwise.

**Resolution** - The specific action(s) recommended to resolve the Human Engineering Comment are described.

**Status** - This column is used to track the resolution of each Human Engineering Comment that is identified.

## 2.3 Preparation of Recommendations for Interventions to Resolve Human Performance Problems in ECS COTS GUI Integration

The third step of the effort was to outline a set of cost-effective interventions/ recommendations to resolve the human engineering problems that limit the creation of an overall effective GUI integration for ECS. The human engineering comments for the assessed products were reviewed, along with the assessments of product potential for reconfigurability. Recommendations were prepared to address training, modifications to GUIs, or other interventions that can foster an effective integration of GUIs among ECS operator/user interfaces regardless of type.

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## 3. Results

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This section presents the results of the initial analysis of software products used in ECS job functions and the results of the Human Factors Evaluation described in the previous chapter. Separate subsections present the matrix identifying ECS operator/user roles or job functions with the software applications these job functions require and summarizing the evaluation results for each of the assessed COTS products (*Autosys/Xpert*, *HP OpenView*, *Remedy*, *SYBASE*, and *Z-Mail*).

### 3.1 ECS Job Functions and GUI Environments Matrix

Figures 3.1-1a and 3.1-1b present the matrix identifying the GUI environments likely to be encountered by operators/users in ECS job functions. The operators/users/job functions are arrayed along the left side of the matrix, and the GUI environments are arrayed along the top. A black dot at the intersection of a row and column in the matrix indicates that the job function in that row will require interaction with the GUI environment for the software product or application identified at the head of that column.

As the figures show, most of the job functions associated with ECS will require interaction with several ECS software products. Many of these products will be ECS custom-developed software, but some job functions will require interaction with a significant number of COTS/OTS products. Specifically, interaction with a large number of specialized COTS/OTS products selected for ECS-specific functions (as opposed to products selected for general ancillary functions such as electronic mail, web browsers, bulletin boards, and news groups) will be required for the Computer Operator, Operations Supervisor, Resource Planner, and Resource Manager. Other system job functions (e.g., Software Maintenance Engineer, System Test Engineer, Science Data Specialist, Production Planner, Production Monitor, and User Services Representative) will also require interaction with a variety of COTS/OTS products.

For human factors assessment, it was desirable to select applications on the basis of two criteria combined: (1) their use in a large number of job functions, and (2) their use in conjunction with others used in the same job functions. Large numbers of job functions will require interaction with custom-developed Motif-based and HTML products for management data access and other ECS subsystem interfaces. The interfaces for these products are anticipated to be designed in accordance with guidance provided in the *ECS User Interface Style Guide*, and so the focus was on COTS applications instead.

As noted subsequently, specialized COTS products selected for ECS-specific functions are the focus of attention for this effort. However, many ECS job functions will entail interaction with COTS products selected for general ancillary functions. For example, the use of *Z-Mail* is projected for every listed job function.

[illegible]

[illegible]

**Figure 3.1-1b. Product Use by ECS Operators/Users in SMC, SEO/LS Functions, and Other Settings**

The interface for this product was reviewed for compatibility or capability for tailoring to be compliant with the requirements of the *ECS User Interface Style Guide*. Other general applications include web browsers, bulletin boards, and news groups. Any recommended interventions to achieve a common look and feel for ECS interfaces will include these COTS products as appropriate. Furthermore, as noted in the figure, it is anticipated that the desktop for every ECS job function will eventually be the Common Desktop Environment (CDE). The figure also illustrates the reliance of ECS on Unix, and notes that every ECS job function is likely to involve running Unix scripts. Interventions affecting these products will be limited.

Looking at the pattern of job functions projected to require interaction with specialized COT/OTS products, it is possible to identify several major products with which interaction will be required for a majority of job functions. These products are: *OpenView*, *Remedy*, *SYBASE*, and *AutoSys/AutoXpert*. Also important for its role in maintaining system availability is *Tivoli*, a fault performance management tool. The human factors review examined these products along with *Z-Mail*.

Other specialized COTS/OTS products will be considered in the context of their anticipated use. For example, tools for configuration management (CM) functions will be used by CM administrators in managing hardware and software problems and changes. Thus, *Clearcase* (for software CM), *DDTS* (for change request management), *Physical Network Manager* (for hardware CM), and *XRP II* (for baseline management) will be used in CM functions and any recommended interventions should ensure that these products are optimized as far as possible for a consistent look and feel. Similarly, it is anticipated that users will access the Release A system through *V0* and will use tools such as *EOSView* for data visualization and *Interactive Design Language (IDL)* for data visualization and manipulation. These products should be considered together for an optimized consistent look and feel. Algorithm development tools and code checkers constitute another cluster to be considered together.

### **3.2 Human Factors Assessment of the *AutoSys/Xpert* COTS Products**

*AutoSys/Xpert* (hereafter *AutoSys*) appears to possess the functionality required by ECS to support data processing requirements. *AutoSys* is a Motif-based program for scheduling and tracking automated software processes in distributed UNIX environments. As such, *AutoSys* provides an automated job control system for scheduling, monitoring, and reporting on jobs that reside in any machine that is attached to a network. *AutoSys* 'jobs' can be scheduled to commence automatically based upon the achievement of preset conditions (that can be set by the operator). The operator selectable criteria that define these conditions include, for example, the completion of previous jobs that are related, the arrival of files, the occurrence of a specified date and time, or any combination of the aforementioned. *AutoSys* allows operators to monitor the progress of jobs and to track events in the job flow so that corrective actions can be taken if required. Operators can also generate reports using an *AutoSys* report generation tool that provides print outs of recorded events or other data used in problem tracking.

An Operator Console motif is provided for the operator. This console motif provides a method of monitoring *AutoSys* jobs in real-time. This feature lets the operator view any jobs that are defined to *AutoSys* whether or not they are currently active. An Alarm Manager is provided which allows the monitoring of alarms as they are generated.

Table 3.2-1 lists the problems identified during the human factors assessment. The table also indicates criticality of each problem, proposed/preferred resolution, and status. A number of these proposed resolutions require further investigation with the *AutoSys* developer in order to determine the degree to which they might address and resolve the problems cited in this assessment.

Even though *AutoSys* provides the necessary functionality for the ECS program tasks for which it was chosen, there are a number of potential problems that may cause operator performance errors and/or productivity problems induced by the design of *AutoSys*. Of the comments shown in the table, a number of them are considered to be critical.

The most critical issue involving *AutoSys* stems from the complexity of the problem that the software is designed to address and manage. The monitoring, tracking, and trouble-shooting of multiple, complex and interactive, automated processes is a challenging human performance problem that requires the most skillful and experienced operators. Monitoring, tracking, and troubleshooting skills are generally classified using the term 'situation awareness'. Situation awareness is a human cognitive, problem solving behavior that is imprecisely understood, but whose importance to complex system functioning is indisputable. To maintain situation awareness an operator must understand the current state of the system.<sup>1</sup> The failure to do so may only be important when data processing failures occur.

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<sup>1</sup>To control a system, an operator must understand its current state. To correct a system failure, an operator must diagnose the failure. Diagnosis requires knowledge of the state of the system and its failure modes. Situation awareness therefore, is a function of the knowledge of the operator regarding the state of the system, its potential failure modes, and the means available to insert corrections into the system to return the system to a normal state. Software such as *AutoSys* is designed to support the operator's information requirements to monitor, track, diagnose (or troubleshoot), and correct system performance errors when they occur. *AutoSys*, therefore, as far as the Data Processing Subsystem is concerned, is designed to support the operator's situation awareness of the status of all ongoing data processing jobs, such that all jobs are processed as desired and data processing failures/errors are detected, diagnosed, and resolved on a timely basis. An acceptable GUI will not reduce the complexity of the situation awareness problem, but a poor GUI design will make a complex problem unmanageable.

**Table 3.2-1. Human Engineering Comments for the AutoSys Tool (1 of 2)**

Human Engineering Comments	Criticality	Resolution	Status
<p>Maintaining operator situation aware-ness during fault/error management of multiple data processing jobs (i.e., &gt;3?) may result in operator performance errors of omission. The errors may be caused/induced by: (1) the complexity of the problem addressed by the soft-ware and (2) the design of the AutoSys Timescape and Jobscape GUIs</p> <p>(NOTE: see page 13-7 of AutoSys User Manual, entitled: Event Processor Cascading Errors)</p> <ul style="list-style-type: none"> <li>- Lack of a clear status tracking overview manager</li> <li>- Lack of a clear error summary and navigation manager</li> <li>- Determine the upper limit of the number of jobs that can be effectively tracked</li> <li>- Determine the upper limit of the number of errors that can be effectively managed (recognized, diagnosed, resolved)</li> <li>- Compatibility of the fault/error management tool with M&amp;O operator monitoring and search/diagnostic behavior</li> </ul>	Critical	<p>Overall resolution of this source of operator performance errors may be problematic, due to the complex nature of the problem that the software attempts to address</p> <p>Primary impact will be on operator training (anticipated to be extensive)</p> <p>Adversely affects operator situation awareness and fault/error management</p> <p>An operability study is recommended as the best means to address this issue.</p> <p>Some AutoSys tools support the operator in process monitoring, e.g., an alarm manager. However, it must be activated by the operator.</p>	New issue opened 8/24/95
<p>Use of color coding as the primary coding convention on the Timescape, Jobscape , and Hostscape displays</p> <p>ECS Style Guide - 2.2.7.2 &amp; 3.3.11.5 NASA - 2.3.1 (Items #1 and #3)</p>	Important	<p>Problematic, currently hardwired into the current release of the product</p> <p>Colors may be modifiable to color combinations or gray scale tones that have adequate contrast that accommodates colorblind operators</p>	New issue opened 8/24/95
<p>Counterintuitive layout of job processing status on the Jobscape display</p> <p>NASA - 3.1.1 (Item #9) &amp; 3.1.2 (Item #8)</p>	Important	<p>Problematic, currently hardwired into the current release of the product; discussions with the PDS development team indicates that Platinum Technology may be changing this in next release</p> <p>Actively explore solutions with Platinum Technologies</p>	New issue opened 8/24/95
<p>Availability/tailoring of GUI navigation tools that are consistent with the ECS Style Guide</p> <p>ECS Style Guide - 5.</p>	Important	<p>Needs exploration with DPS development team to assess ability to support design requirement</p> <p>Suggest development of an application that allows operator to toggle between HostScape, JobScape, &amp; Timescape that is similar in look and feel to other ECS applications</p>	New issue opened 8/24/95
<p>Excessive proliferation of GUI Motifs increases the perceived complexity of tool</p> <ul style="list-style-type: none"> <li>- Timescape: Gantt chart motif</li> <li>- Jobscape: Gantt dependencies chart motif</li> <li>- Hostscape: index card motif</li> <li>- Operator console: form filling motif</li> </ul> <p>ECS Style Guide - 3.3.11.1</p>	Important	<p>Problematic, may be indicative of the complexity of the problem that the software is designed to address</p> <p>Primary impact on operator training (anticipated to require substantial familiarity and hands-on exercises)</p>	New issue opened 8/24/95

**Table 3.2-1. Human Engineering Comments for the AutoSys Tool (2 of 2)**

Human Engineering Comments	Criticality	Resolution	Status
No on-line help system  ECS Style Guide - 2.2.4.10 & 3.5	Critical	Problematic, not currently hardwired into the product; adversely affects the usability of the product and will increase training burdens  No evidence of on-line help (any type of help) in the documentation	New issue opened 8/24/95
AutoSys GUI control panel does not provide accelerator or hot key activation interactions through the keyboard  ECS Style Guide - 2.2.4.10 & 3.3.11.4	Advisory Notice	Problematic, this capability is presently not supported; suggestion that function keys may be reprogrammed needs to be investigated	New issue opened 8/24/95
Ambiguous use of color code selected to identify job status (i.e., differentiate between a job in processing and a job waiting to commence processing)  ECS Style Guide - 3.3.11.5	Important	Problematic, this capability is not currently hardwired into the product; adversely affects operator situation awareness	New issue opened 8/24/95

The use of *AutoSys* by operators to monitor, track, and troubleshoot multiple data processing jobs can be a potential source of operator performance errors of omission,<sup>2</sup> due directly to the expectation that operators will have difficulty in maintaining situation awareness of the system's behavior and status--particularly when data processing errors are induced by common cause or common mode failures.

Further, the current design of *AutoSys* GUIs may contribute to a concern that operators will have difficulty in maintaining situation awareness. In particular, the amount of space allocated to tracking ongoing data processing tasks in the Jobscape display limits to a few the number of data processing jobs that can be observed at one time. If multiple failures/errors in data processing jobs occur, it will be taxing for the operator to maintain situation awareness of each, particularly when common cause and common mode failures/errors occur. Consequently, it is recommended that opportunities for reducing the complexity of monitoring, tracking, and troubleshooting tasks be sought out and implemented in the Data Processing Subsystem, whenever possible. Most of the other human engineering comments shown in the table reflect this concern for situation awareness in fault/error management conditions.

### **3.2.1 Assessment of the Degree of Reconfigurability of the *AutoSys* COTS for Compliance with the *ECS User Interface Style Guide***

As designed, *AutoSys* appears to provide limited opportunities for customization of its GUIs to achieve compliance with the *ECS User Interface Style Guide* and with emerging ECS developmental GUI concepts. Specifically, it provides the ability to modify user preferences to

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<sup>2</sup>Errors of omission occur when an operator action is required and the operator fails to perform the action. These errors often occur for a variety of reasons, e.g., (a) the system does not adequately prompt the operator, (b) the operator does not detect the need to perform a task, (c) the operator forgets to perform the task.

select colors, fonts, and font sizes. However, it does not appear that the current configuration of the software can be modified to achieve the desired look and feel required by the *ECS User Interface Style Guide*.

The feasibility of initiating *AutoSys* using the ECS tabbed form navigation concept should be investigated to determine the extent to which a consistent screen navigation model can be used by the Data Processing Subsystem. One approach might be to activate *AutoSys* (in its own Motif window/s) using icon-activated UNIX scripts that provide instructions for managing the appearance of *AutoSys* on the CRT display.

The absence of key operator aids, i.e. on-line help and keyboard accelerator keys, limits the cost-effective customization of the *AutoSys* tools to comply with the *ECS User Interface Style Guide*. These aids, required in all Motif interfaces, should be part of the product delivered by Platinum Technology.

### **3.2.2 Resolution of Concerns Regarding Operator Situation Awareness Under Data Processing Fault/Error Management Conditions**

An analysis needs to be conducted to determine the extent to which complex common cause and common mode data processing faults/errors occur that would result in data processing system failure. Depending on the estimated frequency of occurrence of incidents of these types and ECS readiness to respond, it is recommended that two strategies be employed to enhance operator situation awareness to avoid and manage data processing faults/errors that occur when multiple data processing jobs are ongoing simultaneously. The first strategy is to leverage any influence that ECS may have with the *AutoSys* developer to resolve the human factors problems identified in Table 3.2-1. This will not eliminate the underlying complexity of the task, however, it will ensure that the design of the software does not contribute to operator performance errors that might occur. The second strategy is to develop hands-on training designed to enhance operator skill in maintaining situation awareness. Specifically, this training should be designed to enhance operator skills in monitoring, tracking, and troubleshooting data processing faults/errors that might occur when multiple and complex data processing jobs occur.

## **3.3 Human Factors Assessment of the HP *OpenView* COTS Product**

HP *OpenView* appears to support the functionality required of the product to monitor and control elements of the ECS network. HP *OpenView*, using an advanced graphical user interface (GUI) is designed to integrate the presentation of network management and systems management applications.

HP *OpenView* Windows (OVW) creates, displays, and continuously updates a graphical map that represents the topology of a network(s). The map display is operator interactive. Status changes in the network are displayed through color changes that occur on the map display. OVW updates the status of the map in real time, displaying the condition of systems and the network as they change.

For each map, OVW creates an environment of interactive windows called Submaps. A Submap is a schematic representation of all or part of the network map. Each submap is a different view of the same network map. The map gives operators control over a collection of submaps. Submaps are representations of network segments and connections. Operators can choose how to reorganize the network display.

Even though HP *OpenView* provides the necessary functionality for the ECS Program tasks for which it was chosen, there are a number of concerns regarding how information is displayed to the operator in terms of processes monitored by this software product. Of the problems areas cited for HP *OpenView*, most can be described as important or advisory notices. One issue is considered to be critical, on the basis of concerns with respect to the complexity of the problem addressed by the software -- as opposed to the design of the software.

Table 3.3-1 lists each problem identified during the human factors evaluation. The table consists of four columns that define the nature of the problem and indicate its overall criticality, status, and proposed resolution.

The most critical issue involving *OpenView* stems from the complexity of the problem that the software is designed to address and manage. The monitoring, tracking, and troubleshooting of multiple, complex and interactive, automated fault management processes is a challenging human performance problem that requires the most skillful and experienced operators. Monitoring, tracking, and troubleshooting skills, classified using the term 'situation awareness' is a human cognitive, problem solving behavior that is imprecisely understood, but whose importance to complex system functioning is well recognized. To maintain situation awareness an operator must understand the current state of the system.<sup>3</sup> The failure to do so may only be important when data processing failures occur.

The use of *OpenView* by operators to monitor, track, and troubleshoot fault management operations can be a potential source of operator performance errors of omission, due directly to the expectation that operators will have difficulty in maintaining situation awareness of the system's behavior and status--particularly when faults or errors are induced by a common cause or common mode.

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<sup>3</sup>See footnote 1 for a definition of situation awareness. Situation awareness applies to the fault management aspects of OpenView. OpenView is designed to support the operator's information requirements while monitoring, tracking, diagnosing (or troubleshooting), and correcting system and network performance faults, when they occur. OpenView, therefore, as far as the Management Subsystem is concerned, is designed to support the operator's situation awareness of the status of system and network operations, such that the system and network operations are fully maintained and hardware and software faults/failures/errors are detected, diagnosed, and resolved on a timely basis. An acceptable GUI will not reduce the complexity of the situation awareness problem, but a poor GUI design will make a complex problem unmanageable.

**Table 3.3-1. Human engineering comments for the HP OpenView tool  
(1 of 2)**

Human Engineering Comments	Criticality	Resolution	Status
Use of identical pull-down menus on the primary window and secondary windows, among other things, permits the operator to exit the application from all screens. This may result in a destructive loss of data.  ECS Style Guide - 2.2.4.1	Important	This comment needs to be investigated. Modifying pull-down menus or graying of undesirable menu choices as inactive may be possible. The preferred solution is to have the pull-down menu located on the primary window only, so that exiting the application can occur only from the primary window.	New issue opened 8/25/95
Lack of an ability to toggle between GUI screens by means of keyboard function keystrokes. This may be important given the need to make use of full-screen mode to optimize the display of important, but otherwise illegible GUI screens.  ECS Style Guide - 2.2.4.9	Advisory notice	This comment needs to be investigated. According to the manual, accelerator keys may be programmable. The preferred solution is to support the use of Motif-compliant function key combinations	New issue opened 8/25/95
As it stands, the network topology map display is too small to be legible and may induce eye fatigue and possibly strain. To compensate, operator will have to use full-screen mode to enlarge display to marginally improve legibility.  Smith & Mosier - 2.4-13 Zooming for display expansion Smith & Mosier - 2.4.8-10 Panning for flexible display framing	Important	This comment needs to be investigated, the COTS GUI may be somewhat customizable. If so, the preferred solution is to support resizing of network map elements, scrolling in a paned window, and/or zoom functions.	New issue opened 8/25/95
Lack of an ability to zoom or pan network map display  Smith & Mosier - 2.4-13 Zooming for display expansion Smith & Mosier - 2.4.8-10 Panning for flexible display framing	Important	See above	New issue opened 8/25/95
The two previous comments address the legibility of screen elements by operators and the use of full-screen mode to compensate for the poor legibility. Any necessity for operators to use the full-screen mode for data and network map displays conflicts with the use of overlapping windows design. Full-screen mode prevents the operator from observing information presented in the windows hidden behind the full screen display. Reducing the size of windows to accommodate multiple screen displays, results in reduced legibility and visibility of data presented in each reduced window.  NASA - 3.3.1	Important	See above two discrepancies.	New issue opened 8/25/95

**Table 3.3-1. Human engineering comments for the HP OpenView tool  
(2 of 2)**

Human Engineering Comments	Criticality	Resolution	Status
Lack of operator feedback regarding the duration of lengthy background processing, particularly network-based processing. For example, the dialog that presents the location of submaps, fails to provide cues to the operator as to the anticipated duration of this processing operation.  ECS Style Guide - 2.2.7.4 & 3.3.11.3	Advisory Notice	Problematic, due to COTS nature of this product. Preferred solution is to provide a progress indicator message box to warn the operator of a time consuming back-ground process and provides an ability to cancel the operation.	New issue opened 8/25/95
Font sizes and color usages are not in conformance with the <i>ECS User Interface Style Guide</i> , that may in combination with other human engineering comments affect the usability of the product.  ECS Style Guide - 2.2.7.1, 3.2.6, 3.3.11.6, & Appendix B	Advisory Notice	These attributes should be modified by changing the X-app defaults.	New issue opened 8/25/95
Color as a primary coding convention to alert operators to status changes in the network. Violates rule that color should be a redundant cue rather than the sole indicator for a function; may increase errors because a relatively large percentage of operators/users (particularly men) will be color weak.  ECS Style Guide - 2.2.7.2 & 3.3.11.5	Important	Problematic. Preferred solution is to apply an alternate coding convention.	New issue opened 8/31/95
It is unclear how well OpenView supports the monitoring, situation awareness, and diagnostic needs of the operator for fault management operations that involve common cause or common mode failures of equipment and software. Monitoring, situation awareness, and diagnosis are complex and specialized operator skills that are time consuming to obtain and possibly are sensitive to rapid forgetting.	Critical	Problematic, due to the complexity of the problem that the software is designed to manage.  Predicted impact is on training and the level of expertise required of the operator.  Addressing a number of the human engineering comments shown above will enhance operator response in these more severe failure conditions.	New issue opened 8/25/95

Further, the current design of *OpenView* GUIs may contribute to a concern that operators will have difficulty in maintaining situation awareness. In particular, the poor legibility of the network topology map may delay operator response to system or network failures that occur when the operator is in a normal monitoring mode. Further, it may complicate fault diagnosis, to the extent that operators depend on it as a means to navigate through the representation of systems and networks for possible failures and failure modes. If multiple network faults or errors occur, it will be taxing the operator to maintain situation awareness of each, particularly when their origins are of a common cause or common mode nature. Consequently, it is recommended that opportunities for reducing the complexity of monitoring, tracking, and troubleshooting tasks

be sought out and implemented in the Management Subsystem, whenever possible. Most of the other human engineering comments shown in the table contribute to this concern for situation awareness in fault/error management conditions.

### **3.3.1 Assessment of the Degree of Reconfigurability of the HP *OpenView* COTS for Compliance with the *ECS User Interface Style Guide***

HP *OpenView* provides limited capabilities for customization of its GUIs to achieve compliance with the *ECS User Interface Style Guide* and with emerging ECS developmental GUI concepts. Specifically, it provides the ability to modify user preferences to select colors, fonts, and font sizes. However, it may not be practical to modify the look and feel of most features of HP *OpenView*, because the complexity of the problems managed by the software presents a substantial challenge to software and operators alike under the condition of multiple ongoing processes.

An examination of the feasibility of initiating HP *OpenView* using the ECS tabbed form navigation concept is necessary in order to determine the extent to which a consistent screen navigation model can be used by the Management Subsystem, among others. One approach is to activate HP *OpenView* (in its own Motif window/s) using icon-activated UNIX scripts that provide instructions for managing the appearance of HP *OpenView* on the CRT display.

The absence of key operator aids (e.g., keyboard accelerator keys) limits the cost effective customization of the HP *OpenView* tools to comply with the *ECS User Interface Style Guide*.

### **3.3.2 Resolution of Concerns Regarding Operator Situation Awareness Under Data Processing Fault/Error Management Conditions**

An analysis needs to be conducted to determine the extent to which complex common cause and common mode system and network faults/failures/errors occur that would result in ECS failure. Depending on the estimated frequency of occurrence of incidents of these types and ECS readiness to respond, it is recommended that two strategies be employed to enhance operator situation awareness to manage ECS network faults/errors that occur when complex system or network faults occur or when multiple nodes fail simultaneously. The first strategy is to tailor the *OpenView* GUIs to resolve the human factors problems identified in Table 3.3-1 to the maximum extent possible. This will not eliminate the underlying complexity of the task, however, it will reduce the likelihood that the design of the software induces operator performance errors. The second strategy is to develop hands-on training designed to enhance operator skill in maintaining situation awareness. Specifically, this training should be designed to enhance operator skills in monitoring, tracking, and troubleshooting network faults/errors that might occur when multiple and complex faults occur and/or multiple network nodes are involved.

### 3.4 Human Factors Assessment of the *Remedy* COTS Product

*Remedy's Action Request System* (AR System) is a versatile and flexible product with capability to be reconfigured/customized for close conformance with the *ECS User Interface Style Guide*. The AR System provides operators with tools to manage support requests and problems. Entries made into the AR System reference a database of problem solving experience. The AR System can be used to track and report on a variety of issues, information, and problems.

The AR System appears to be flexible and highly customizable in terms of workflow and GUIs. Functionally, ECS operators will utilize the AR System to submit action requests, enter problem resolutions and create reports when necessary.

The AR System appears to provide the necessary functionality for the ECS Program tasks for which it was chosen. However, a few problem areas were identified in the human factors assessment in terms of the user interface. Table 3.4-1 breaks down all problem areas of *Remedy's AR System* as it is currently configured for the ECS program. The table indicates criticality of the problem, status, and proposes resolutions whenever possible and appropriate.

#### 3.4.1 Assessment of the Degree of Reconfigurability of the *Remedy* COTS for Compliance with the *ECS User Interface Style Guide*

*Remedy* provides extensive capabilities for customization of its GUIs to achieve compliance with the *ECS User Interface Style Guide* and with emerging ECS developmental GUI concepts. Specifically, it provides the ability to modify user preferences to select colors, fonts, and font sizes.

**Table 3.4-1. Human Engineering Comments for the *Remedy* Tool**

Human Engineering Comments	Criticality	Resolution	Status
Dismiss command used instead of the Motif standard Close command on pushbuttons  ECS Style Guide - 3.3.11.1 NASA - 1.1.3	Advisory Notice	Problematic, due to COTS nature of the product.	New issue opened 8/25/95
Fonts, font sizes, and color usages do not conform to the ECS User Interface Style Guide  ECS Style Guide - 2.2.7.1, 3.2.6, 3.3.11.6, & Appendix B	Important	Change X-app default for the product and/or use AR User Tool to customize defaults, views, sort options, and create commands.	New issue opened 8/25/95
Changes in font sizes may require redistribution of screen elements by operators to eliminate overlapping.  ECS Style Guide - 3.3.11.3	Important	Verify whether this problem obtains by further investigation.  Preferred solution is to design to avoid operator modification of defaults as delivered to the operator.	New issue opened 8/25/95

An examination of the feasibility of initiating *Remedy* using the ECS tabbed form navigation concept is necessary in order to determine the extent to which a consistent screen navigation model can be used by the Management Subsystem, among others. One approach is to activate *Remedy* (in its own Motif window/s) using icon-activated UNIX scripts that provide instructions for managing the appearance of *Remedy* on the CRT display.

### **3.5 Human Factors Assessment of the SYBASE COTS Product**

*SYBASE* is the primary database engine for ECS. Its several functions are based on the Structured Query Language (SQL) and include a Data Workbench, Structured Query Report (SQR) Writer, SQL Server Manager, and System Administrator's (SA) Companion. These are accessible through essentially character-based user interfaces (CHUIs), rather than Motif-based GUIs. Most ECS operator/user access to *SYBASE*, however, will occur via custom-GUIs or COTS/OTS products. Some *SYBASE* products readily support the development of custom interfaces. For example, *Gain Momentum* is a *SYBASE* product that permits rapid development of user-friendly GUI environments, including multimedia. There are only a few situations in which native *SYBASE* CHUIs will be used by operators/users (e.g., the use of SQR functions, or use of the *SYBASE* Data Workbench to create databases; Data Base Administrators will use Sequel Server Manager and SA Companion in the management of ECS data bases). The assessment of *SYBASE* was limited to the *SYBASE* operator/user interface itself and did not address the range of ECS subsystems/functions and GUI environments in which *SYBASE* will be embedded, because they were still in development at the time of this assessment effort. Table 3.5-1 breaks down all problem areas of the *SYBASE* operator/user interface in its native form. The table indicates criticality of the problem, status, and proposes resolutions whenever possible and appropriate.

#### **3.5.1 Assessment of the Degree of Reconfigurability of the SYBASE COTS Products for Compliance with the ECS User Interface Style Guide**

As noted previously, *SYBASE* data base products are not Motif-based, and therefore their operator/user interfaces in their native form will not comply with the *ECS User Interface Style Guide*. It is likely that only operators highly skilled in the use of SQL will elect to attempt interaction with the products using their CHUIs. However, the ease with which compliant GUIs can be created for them makes them readily reconfigurable to the ECS style specified in the *ECS User Interface Style Guide*. There is no reason to burden any operators or users with a requirement to use the native *SYBASE* ChUIs.

**Table 3.5-1. Human Engineering Comments for the  
SYBASE Native Interfaces (1 of 2)**

Human Engineering Comments	Criticality	Resolution	Status
Operator/User interface is character-based; user must focus on application instead of on what must be done to accomplish the task  NASA - 1.1.1	Critical	Avoid all requirement to interact with native SYBASE interfaces; if direct interface with SYBASE is required, create a GUI using a tool such as Gain <i>Momentum</i>	New issue opened 9/7/95
Menu bar does not conform to standard identified in <i>ECS User Interface Style Guide</i> <ul style="list-style-type: none"> <li>File option not clearly marked; it is represented by a character (/) rather than a word</li> <li>Help not right-justified on menu bar; it is found as a choice under file (/)</li> </ul> ECS Style Guide - 3.4.3, 3.4.4 & 3.3.11.7 NASA - 1.5.3	Important	Problematic; interface is not Motif-based.	New issue opened 9/7/95
F1 not used for on-line help  ECS Style Guide 2.2.4.9	Advisory notice	Problematic, due to COTS nature of the interface.  Preferred solution is to develop a GUI using a tool such as Gain <i>Momentum</i> .	New issue opened 9/7/95
Limited flexibility of operations: to access program functions opened by menu selections at a given level, operator must complete and close in sequence all actions associated with prior menu selections at that level  ECS Style Guide 2.2.4.10, 3.3.11.3, & 3.3.11.4	Important	Problematic, due to COTS nature of the interface.  Preferred solution is to develop a GUI using a tool such as Gain <i>Momentum</i> .	New issue opened 9/7/95
Main window not resizable  ECS 3.3.11.3 Motif Style Guide 7.3.6	Important	Problematic, due to COTS nature of the interface.  Preferred solution is to develop a GUI using a tool such as Gain <i>Momentum</i> .	New issue opened 9/7/95
Pull down menus whose options are currently unavailable are not grayed out "per se." The line that the unavailable pulldown option appears on is gray, the rest are white. Frequently, only one option was available, leaving one choice white in a field of gray. This can lead to confusion as operators may interpret the available item to be selected and the unavailable items to be available but not selected. Need to actually "gray out" the text of unavailable choices and not the area around the choice.  NASA 3.4.2 ECS Style Guide 3.3.11.3 Motif Style Guide 6.3.1.6	Important	Problematic, due to COTS nature of the interface.  Primary impact on operator training (anticipated to require substantial familiarity and hands-on exercises)	New issue opened 9/7/95

**Table 3.5-1. Human Engineering Comments for the  
SYBASE Native Interfaces (2 of 2)**

Human Engineering Comments	Criticality	Resolution	Status
Help text is highlighted, which normally connotes hypertext in other ECS GUIs. Does not always work in this application.  ECS 3.3.11.7	Advisory notice	Problematic, due to COTS nature of the interface.  Primary impact on operator training (anticipated to require substantial familiarity and hands-on exercises)	New issue opened 9/7/95
Operator/user interface customizable only to the extent that desktop can be customized  ECS 3.3.9	Important	Problematic due to COTS nature of the interface.  Preferred solution is to develop a GUI using a tool such as Gain <i>Momentum</i> .	New issue opened 9/7/95
Frequently must go through three or more screens to reach desired function; only one method is provided for paging through "screens."  ECS 3.3.11.4 NASA 1.6.1 NASA 3.4.1 - Items #5, #9, & #10	Important	Problematic, due to COTS nature of the interface.  Primary impact on operator training (anticipated to require substantial familiarity and hands-on exercises)	New issue opened 9/7/95
Failure to make clear distinctions between different elements of display format; inactive "window" looks the same as active parts of screen.  NASA 3.1.1 - Item #1	Critical	Problematic, due to COTS nature of the interface.  Primary impact on operator training (anticipated to require substantial familiarity and hands-on exercises) Preferred solution is to develop a GUI using a tool such as Gain <i>Momentum</i> .	New issue opened 9/7/95
Takes several distinct operations to close certain subwindows.  ECS Style Guide 3.3.11.3 NASA 3.4.1 - Item #5 Smith & Mosier 3.3.1	Important	Problematic due to COTS nature of the interface.  Preferred solution is to develop a GUI using a tool such as Gain <i>Momentum</i> .	New issue opened 9/7/95
Unable to escape certain fields or cancel certain operations. (e.g. SQL Batch Editor does not let user exit until all data fields are completed correctly.)  ECS Style Guide 3.3.11.3 NASA 3.4.1 - Item #5 Smith & Mosier 3.3.1	Important	Problematic due to COTS nature of the interface.  Preferred solution is to develop a GUI using a tool such as Gain <i>Momentum</i> .	New issue opened 9/7/95
On-line Help is not multi-level.  NASA 1.5.3	Important	Problematic; nature of the application.	New issue opened 9/7/95

### 3.6 Human Factors Assessment of the *Z-mail* COTS Product

*Z-mail* has been chosen by ECS to provide electronic mail services. It seems to possess all the functionality that is required of the product. *Z-mail* is easily customizable through manipulation of an X-app defaults file and through tools that are available to the operator/user within the

application. By making appropriate modifications to the X-app defaults file, this interface can be brought into compliance with the *ECS User Interface Style Guide* and achieve a similar "look and feel" to other compliant applications.

Overall, *Z-mail* conforms closely to the *ECS User Interface Style Guide*. However, the Human Factors Assessment identified some minor problem areas in terms of the interface. Table 3.6-1 details problem areas identified during the human factors assessment, indicates the criticality and proposes resolutions for each. Even though there were areas identified as non-compliant with the Style Guide, these problems areas are not potential sources for operator/user performance error.

### 3.6.1 Assessment of the Degree of Reconfigurability of the *Z-mail* COTS Product for Compliance with the *ECS User Interface Style Guide*

The appearance of the *Z-mail* interface is highly customizable in terms of color and font size. As previously mentioned, the X-app defaults file can be modified to make the interface compliant with the *ECS User Interface Style Guide*. Also, tools are available to the operator/user to customize these aspects of the interface to personal preference. The overall look and feel of the *Z-mail* GUI are fixed; but are, for the most part, compliant with the Style Guide.

**Table 3.6-1. Human Engineering Comments for the Z-Mail Product**

Human Engineering Comments	Criticality	Resolution	Status
Font sizes and color usages are not in conformance with the <i>ECS User Interface Style Guide</i>  ECS Style Guide - 2.2.7.1, 3.2.6, 3.3.11.6, & Appendix B	Advisory Notice	These attributes should be modified by changing the X-app defaults file.	New issue opened 9/5/95.
Non-Standard PushButton Labels (e.g. "Done" vs. "OK")  ECS Style Guide - 3.3.2	Advisory Notice	Problematic. Appears to be hardwired into the application and not modifiable.	New issue opened 9/5/95
Pop-up labels are not activated for icons buttons. Pixmap images are the only source of identification for the function of icons on the tool bar.  ECS Style Guide - Figure 3.1.1-6	Advisory Notice	Icons probably generated from a widget library. If so, modify widget resources of toolbar to activate pop labels.	New Issue opened 9/5/95

## 3.7 Cross-Product Compatibility of the GUIs for ECS Software

The cross-product compatibility of the GUIs (COTS, OTS, custom-coded, or HTML) for ECS software is as important to the usability of ECS GUIs as the usability of each application independently. Therefore, the human factors implications of combining a variety of GUIs into the ECS desktop was evaluated. The human factors comments associated with this assessment are shown in Table 3.7-1. The discussion that follows discusses these comments in some detail.

**Table 3.7-1. Human Engineering Comments on Cross-Application Compatibility**

Human Engineering Comments	Criticality	Resolution	Status
<p>Potential that operators/users (particularly infrequent or inexperienced operators/users) will:</p> <p>(a) have difficulty in distinguishing the windows of one application from the others, when multiple applications (COTS, OTS, custom-coded, or HTML-based) using multiple overlapping windows are employed simultaneously</p> <p>(b) have difficulty in: (1) efficiently orienting themselves to the system functionality required to accomplish the task at hand, (2) navigating through the GUIs to accomplish sequences of related tasks, and (3) maintaining visibility of all screen elements that contain information relevant to the completion of specified tasks.</p>	Important	<p>Applications should be developed/tailored/used in a manner that minimizes the dependence on separate windows to accomplish related functions</p> <p>Adherence to a GUI navigation technique (i.e., tabbed form that arranges screen layout on the basis of distinct functions) can assist in minimizing the use of multiple overlapping windows and achieve operator focus to the ongoing function</p>	New issue opened 9/7/95
Cross-product clustering of GUI metaphors/paradigms that might induce operator/user performance errors (e.g., reversals in keyboard assignments or mouse operations that lead to a destructive loss of data)	Advisory Notice	<p>Developers need to be aware that GUI paradigms that define the behavior of the GUI may in combination with one another induce operator/user performance errors</p> <p>Developers should observe, test, and minimize the occurrence of such situations</p>	New issue opened 9/7/95

### 3.7.1 Diversity of ECS GUI Environments

As stated above, the review of COTS GUIs revealed the potential for combining an extremely diverse range of COTS GUIs into the ECS desktop for use by operators/users. It is anticipated that this diversity in GUI environments will have the greatest effect on ECS operators. Potential adverse effects include (a) increased amount and duration of training, (b) design-induced operator/user performance errors, and (c) design-induced productivity decrements (e.g., takes longer, more labor, lower quality). Therefore, a discussion of the diversity of GUI environments across ECS operators/users is instructive in addressing human factors problems related to it.

The broad categories of GUI environments include:

- COTS Motif applications (commercially supported by vendors; examples include HP *OpenView*, *AutoSys/AutoXpert*, *Remedy*)
- OTS Motif applications (in-house maintenance and support by ECS; examples include *V0*, *EOSView*)
- OTS C/C++ applications (in-house by ECS or government supported under separate contract; examples include NCSA *Mosaic*)
- COTS character-based user interface (ChUI) applications (commercially supported by vendors; examples include *SYBASE's* Data Workbench tool)

- e. ECS Motif developmental applications (developed and maintained by ECS in accordance with project specifications and the *ECS User Interface Style Guide*; examples include the Planning Subsystem, Ingest Subsystem)
- f. ECS HTML developmental applications (developed and maintained by ECS in accordance with project specifications and the ECS User Interface Style Guide; examples include developmental applications that support the Ingest Subsystem, Data Server Subsystem, and the Client and Interoperability Data Management Subsystem).

With the exception of the user roles (Science User, Non-Science User, and Service Providers listed in Figure 3.1-1), only the operators will be exposed to the diverse range of GUI environments (developmental or otherwise) listed above. Given that these personnel are typically represented by the most experienced Unix workstation operators and that they frequently operate in the most complex software environment, they are frequently acclimated to diverse GUI environments. However, training is often a necessary means to ensure operator skill acquisition and sustainment, particularly when new or revised software is introduced into the operating environment.

Users, on the other hand, are generally not expected to employ many of the less common COTS/OTS products listed in Figures 3.1-1a and 3.1-1b. The exceptions are that Science Users will employ *AutoSys/Xpert*, the *IDL* Visualization tool, and a yet to be designated code checker application. Many users will employ common COTS/OTS products including electronic mail, web browsers, bulletin boards, news groups, *V0* client and *EOSView*. Finally, many users will employ a number of the ECS developmental applications (Motif and HTML-based). For these personnel, the cross-product diversity of the GUI environments with which they must contend is less worrisome, than the underlying complexity of individual GUIs (e.g., the *V0* client).

### **3.7.2 Cross-Product Orientation, Navigation, and Interaction with Diverse GUI Environments and Multiple Overlapping Windows**

Based on our review of the GUI environments employed in a number of COTS/OTS products and our understanding of the manner by which ECS subsystem functions will be accomplished, we have determined that most operator/user tasks will be accomplished through the combined use of multiple software applications. The implication of this finding is that cross-product traversal provides a potential source of navigation problems that might affect the accuracy or efficiency of operator/user interaction with ECS. In our reviews of a number of COTS software applications, pull-down menus remain the primary means of activating and closing application windows and related software applications. As one might expect these menuing systems employ widely different structures, each of which must be learned and negotiated in order for operators/users to complete transactions with ECS. This represents a poor mode of traversal between applications and windows that are related to the same software product. Independent software applications provide no means whatever to guide operator/user navigation on cross-product excursions (or traversals).

Motif does not provide intuitive and structured aids to operator/user focus in orienting to the system functionality that is required to accomplish specified tasks. Additionally, Motif provides few real guidelines that aid operator/user navigation through Motif GUIs to provide support to the accomplishment of sequences of tasks. This is compounded by a tendency among Motif developers to assign individual tasks to unique windows (a tendency that is frequently encouraged by the Motif standard). This tendency results in the proliferation of overlapping windows resulting in a cluttered desktop that, over time, becomes complex and difficult for operators to manage and negotiate. At the very least, it reduces productivity through the 'trial and error' searches required for operators/users to locate relevant information and the window(s) within which the information can be found.

The first human engineering comment in Table 3.7-1 defines the human factors problem, its criticality, and identifies a proposed resolution. Developers need to be aware that Motif applications have a tendency to proliferate multiple windows that overlap and that, over time, degrade operator/user performance by becoming a source of confusion. This problem becomes particularly acute to infrequent or inexperienced operators/users when, over time, complex software is replaced with incremental upgrades that modify the look and feel of the GUI.

The *ECS User Interface Style Guide* contains a tabbed form navigation design concept for achieving a consistent look and feel for ECS workbench applications. This design concept provides a way to address the human factors problem cited in this comment.

### **3.7.3 Cross-Product Clustering of GUI Paradigms/Metaphors**

It is clear from our review of a number of COTS products (including AutoSys/AutoXpert, HP OpenView, Sybase, Remedy, and Z-Mail) that each product employs one or more different GUI metaphors ('GUI looks') and GUI paradigms (GUI 'feel' or behaviors). In general, human factors engineers are concerned with the consistency of operator/user interactions within and across software products. The GUI paradigms that define the nature of human-computer transactions can determine the extent to which operator/user performance errors (e.g., function key reversals that result in a destructive loss of data) and productivity decrements are expected to occur. While no instances of human factors problems such as function key reversal were identified in the limited review of a number of COTS products, this does not mean that the potential does not exist for such problems in other software applications.

A factor that might mitigate this problem is the observation, in a number of the COTS products that were the subject of this review, that the GUI paradigms employed in the software tended to accompany and be specific to the GUI metaphors built into the application. On this basis it could be argued that the associations between functionality and tasks that operators/user create when learning to use a software application will mitigate any opportunity that exists for design-induced operator/user performance errors. Simply stated, operators/users won't make errors due to differences in GUI paradigms, because they associate the behavior (the human-computer transaction) to the GUI metaphor to which it is assigned.

The second human engineering comment in Table 3.7-1 defines this human factors problem, its criticality, and identifies a proposed resolution. It is recommended that the resolution proposed in the table be implemented to identify any such problems and resolve them to the extent feasible.

#### **3.7.4 Compliance with the ECS User Interface Style Guide**

Compliance with the ECS User Interface Style Guide, to the extent it is feasible and cost-effective to do so, is recommended as the best means to ensure the cross-product compatibility of the GUI environments supported in ECS. While achieving compliance cannot simplify complex job functions and tasks, it can reduce or eliminate potential sources of operator/user performance error and reduced operator/user productivity tied to inefficiency in the design of the human-computer interface. Also, implementing human-machine interface methodology provides a systematic structure within which to define the human-computer transactions that typify ECS operations. Workflow analysis can be a useful tool in determining which software features of COTS products should be modified or tailored prior to implementation and use by operators/users.

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## 4. Recommended Interventions for COTS Integration

In general, the implementation of the HMI methodology and compliance with the ECS User Interface Style Guide, to the extent it is practical and useful, is recommended as the best means to achieve an effective integration of COTS GUIs with the suite of software to be used in ECS releases. Beyond that a number of specific recommendations for interventions designed to resolve identified human factors problems are discussed below. This chapter is organized around the interventions proposed to resolve human factors problems associated with the COTS products reviewed as well as concerns expressed with cross-product compatibility. Table 4-1 identifies the recommended interventions. The text that follows discusses the most important aspects of the interventions.

**Table 4-1. Recommended Interventions for Ensuring the Effective Integration of COTS GUIs (1 of 2)**

Type of Intervention	Applicable Product	Recommendation
Workflow Analysis	AutoSys/Xpert	Conduct detailed workflow analysis of realistic and relevant data processing fault management scenarios designed to address the monitoring, detection, identification, and resolution of common cause and common mode failures
	HP OpenView	Conduct detailed workflow analysis of realistic and relevant system and network fault management scenarios designed to address the monitoring, detection, identification, and resolution of common cause and common mode failures
Analysis of the Severity and Frequency of Common Cause and Common Mode Failures	AutoSys/Xpert	Conduct an analysis to determine the extent to which data processing faults occur due to a common cause or common mode failure, as a basis for assessing the cost-benefit associated with personnel selection and training interventions that follow
	HP OpenView	Conduct an analysis to determine the extent to which system and network faults occur due to a common cause or common mode failure, as a basis for assessing the cost-benefit associated with personnel selection and training interventions that follow
Personnel Selection/Job Definition	AutoSys/Xpert	Recommend the development and adoption of personnel selection/job definition policies that require demonstrated fault management aptitude (per section 4.2, Establishment of Certification Requirements, contained in the Training Plan for the ECS Project, 622-CD-001-002)
	HP OpenView	Recommend the development and adoption of personnel selection/job definition policies that require demonstrated fault management aptitude (per section 4.2, Establishment of Certification Requirements, contained in the Training Plan for the ECS Project, 622-CD-001-002)
Training and Job Aid Development	AutoSys/Xpert	Develop fault management training and exercises designed to instruct operators on fault management operations associated with data processing failures/errors (especially for common cause and common mode failures) (per section 4.2, Establishment of Certification Requirements, contained in the Training Plan for the ECS Project, 622-CD-001-002)

**Table 4-1. Recommended Interventions for Ensuring the Effective Integration of COTS GUIs (2 of 2)**

Type of Intervention	Applicable Product	Recommendation
Training and Job Aid Development (continued)	HP OpenView	Develop fault management training and exercises and job aids designed to instruct operators on fault management operations associated with system and network failures/errors (especially for common cause and common mode failures) (per section 4.2, Establishment of Certification Requirements, contained in the Training Plan for the ECS Project, 622-CD-001-002)
Tailor COTS GUIs	AutoSys/Xpert (per section 3.2) HP OpenView (per section 3.3) Remedy (per section 3.4) Z-Mail (per section 3.6)  All COTS (per section 3.7)	Tailor the x-app defaults and user preferences of each COTS product to comply with the human factors guidelines contained in the ECS User Interface Style Guide to minimize operator/user performance errors and maximize productivity
Leverage vendor modifications to COTS GUIs	AutoSys/Xpert (per section 3.2)	Leverage ECS status as largest customer for AutoSys to encourage Platinum Technology to resolve GUI problems identified in Table 3.2-1
Encapsulate COTS product with custom GUI(s)	Sybase	Develop custom-coded GUIs for all ECS subsystems that require access to the Sybase database engine. Native Sybase GUIs are non-compliant with the Motif standards and the ECS User Interface Style Guide.

The first four recommendations (two that recommend workflow analysis and two that recommend an engineering analysis to assess the likelihood and severity of failures) are specific to concerns raised during the human factors assessment of the GUIs for the AutoSys/Xpert and the HP OpenView products. Both products are intended to play a substantial role in fault management. Fault management is perhaps the most complex task that operators are assigned. These analyses are required to address concerns that these products limit operator fault management response.

The next four recommendations (two that recommend personnel selection policies and two that recommend training development in fault management) are interventions designed to address shortcomings in the proposed COTS products (AutoSys/Xpert and HP OpenView) with respect to the support provided to operators in responding to common cause or common mode failures. The implementation is dependent upon the outcome of the preceding four analysis recommendations. To the extent that these concerns are genuine (as reflected in an engineering analysis that identifies the frequency and severity of such failures), it may or may not be cost-effective to implement these interventions.

The recommendations associated with the type of intervention entitled 'Tailor COTS GUIs' are offered as cost-effective measures to reduce/eliminate causes of design-induced operator/user performance error and increase productivity. The specific recommendations for each COTS product that was reviewed are described in the appropriate section of chapter 3, Results.

The recommendations associated with the type of intervention entitled 'Leverage vendor modifications to COTS GUIs' reflect an opportunity to leverage ECS's relationship with the vendor for the AutoSys/Xpert product, as their largest customer. Additionally, it is our understanding that Platinum Technology has an ongoing development effort to improve their technology and appear open to suggestions from ECS. A number of recommendations listed in Table 3.2-1 should be shared with Platinum Technology for their resolution. These changes will enhance their product and improve ECS operations that require its use.

The final intervention is the recommendation that all usages of the Sybase product require the development and implementation of custom-developed GUIs to access the Sybase database engine. This should not be a significant issue since most if not all ECS developers appear to be moving in that direction anyway. This intervention is designed to prevent the use of native Sybase ChUIs in all cases.

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## **5. SCDO (Combined Release A, Release B, and M&O) Response**

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The following represents the SCDO (combined Release A and B) response to the recommendations contained in this report. The analysis examined the usage of ECS (COTS, OTS, and custom-developed) GUIs by user (science and non-science) and maintenance & operations personnel. The analysis also examined the GUIs for several COTS products selected for ECS. The Analysis involved evaluation of the compliance of these COTS GUIs with the human factors guidelines contained in the ECS User Interface Style Guide (hereinafter, the Style Guide). Recommendations resulting from the Analysis include conducting workflow analysis, analyzing system behavior, operator training, and tailoring or encapsulating COTS products with custom GUIs.

### **5.1 Overall Endorsement of Report Recommendations and implementation of Specific Actions**

In general, we agree that the recommendations contained in the report will accomplish the Human-Machine Interface (HMI) objectives for ECS; namely to ensure that ECS supports a productive and efficient work flow, and that all GUIs conform to the look and feel prescribed in the Style Guide. Specific recommendations which do not represent a significant risk to the project cost and schedule have already been incorporated into the overall SCDO development program. The remainder of this section describes the SCDO response and actions planned or accomplished, in responding to these specific recommendations.

### **5.2 Response to Specific Recommendations**

The response that follows is organized in accordance with the specific recommendations contained in the Executive Summary (Table ES-1) and section 4. (Table 4-1).

#### **5.2.1 Recommendation #1: Workflow Analysis: AutoSys/Xpert**

Conduct detailed workflow analysis of realistic and relevant data processing fault management scenarios designed to address the monitoring, detection, identification, and resolution of common cause and common mode failures.

##### **5.2.1.1 Response**

The Production Processing Job Anomaly Scenario (section 3.13.2) contained in the *Operations Scenarios for the ECS Project: Release A* (605-CD-001-003; dated January 1996) and its counterpart scenario in the *ECS Operations Concepts Workshop: Release B; Day 3* (727-PP-002-001, dated 17-19 January 1996), present the workflow for the failure of a single production job. This is expected to be the most frequent type of production failure to occur involving DPS.

Under these conditions, AutoSys/Xpert will notify the production monitor (operator), by means of an alarm, of an anomalous production job. This permits the production monitor to monitor, detect, and identify production job failures. Diagnosis and correction of these types of failures are not performed by the production monitor using AutoSys/Xpert. Instead, the DPS will send HP OpenView an event for the AutoSys/Xpert alarm. Then, the DPS will move the temporary output and job logs for the failed PGE to local storage on an appropriate data server for destaging. The diagnostic and correction path is dependent upon identifying what caused the production job failure. In the operations scenario, there is some problem with the PGE. In this case, the production monitor opens a trouble ticket for later diagnosis and resolution by a DAAC data specialist. On the other hand, if there is a hardware or software problem that causes the failure, then the Management Subsystem (MSS) through HP OpenView will address the problem. In these cases, AutoSys/Xpert plays no role in the management of the failure.

The workflow for multiple PGE failures of the kind described in the Production Processing Job Anomaly Scenario can be handled by extension, since the critical path for handling each such failure would be the same regardless of how many were to occur. Complex common mode or common cause failures that involve hardware or software problems, outside of the PGEs, will be handled by MSS through HP OpenView and are discussed in the recommendations for HP OpenView. Therefore, the scenario and workflow that have been prepared address this recommendation.

## **5.2.2 Recommendation #2: Workflow Analysis: HP OpenView**

Conduct detailed workflow analysis of realistic and relevant system and network fault management scenarios designed to address the monitoring, detection, identification, and resolution of common cause and common mode failures.

### **5.2.2.1 Response**

The operations workshops for Release A and Release B have documented a number of scenarios that bear on the workflow for complex fault management situations. These scenarios are contained in *Operations scenarios for the ECS project: Release A* (605-CD-001-003; dated January 1996) and in the Release B counterpart, the *ECS Operations Concepts Workshop: Release B*; (727-PP-002-001, dated 17-19 January 1996). Relevant scenarios include, the production failure scenario (section 3.3.1) from the Release A 605, and the failure during startup scenario (MSS) from the Release B Operations Workshop Day 1 book, and the DM server saturation resolution (DMS) from the Release B Operations Workshop day 3 book.

In each of these scenarios, the workflow is defined such that the operators (e.g., resources manager, production monitor) use HP OpenView to monitor, detect, and identify error events. The resolution (meaning diagnostics and correction activities) of the problems cited in each scenario is addressed by means of the operator communicating (usually through a trouble ticket,

e-mail, telephone or verbal) the problem to other operators for investigation and ultimate resolution of the problem. If required, the operator uses HP OpenView to manage around a problem by rerouting ongoing processing among the available resources.

These scenarios represent the typical pattern for addressing such critical events. The HP OpenView operator will manage each event up to a point and direct the resolution of specific problems to other DAAC operations specialists, who themselves may in turn request outside support, e.g., vendor technicians for specific hardware and COTS software. It is anticipated that through a combination of these means all such critical events will be managed.

### **5.2.3 Recommendation #3: Analysis of the Severity and Frequency of Common Cause and Common Mode Failures: AutoSys/Xpert**

Conduct an analysis to determine the extent to which data processing faults occur due to a common cause or common mode failure, as a basis for assessing the cost-benefit associated with personnel selection and training interventions that follow.

#### **5.2.3.1 Response**

For the reasons expressed in our response to recommendation #1, we question the assumptions underlying this recommendation. It seems to be the concern that a common mode failure will occur that will completely upend the data processing system and that the production monitor will not be able to identify, isolate, diagnose and correct the problem through AutoSys/Xpert. First, far and away the most frequent failure with which production operators will have to contend will be the failure of a single job because of its own internal problems, as defined in the Production Processing Job Anomaly Scenario. These single job failures will not affect the rest of the data processing system because the DPS will solve the problem by getting the production processing remains out of the way so that processing of the next job can start on that processor. In terms of common mode problems that could lead to many jobs failing, failures in the network, data server, or the server supporting the AutoSys/Xpert application come to mind, but the AutoSys/Xpert GUIs are not expected to support the identification and resolution of this type of problem. As stated in our response to recommendation #1, this would be accomplished by the event and error handling capabilities built into MSS.

It would be ideal to quantify the frequency and severity of these hypothetical problems, if the data existed that support them. Unfortunately, at this time, ECS simply lacks the operational history required to determine whether problems of the kind described actually exist, and, if they exist, to quantify their frequency and severity. Likewise, there does not appear to be a similar predecessor system from which to extrapolate such data for the sort of analyses recommended. AutoSys/Xpert is a new product, with a short experience history. Consequently, we recommend that the operational history of these sorts of events be tracked during the actual use of AutoSys/Xpert in the role for which it was designed. Remedial actions could then be undertaken to redress such problems, if identified at that time.

#### **5.2.4 Recommendation #4: Analysis of the Severity and Frequency of Common Cause and Common Mode Failures: HP OpenView**

Conduct an analysis to determine the extent to which system and network faults occur due to a common cause or common mode failure, as a basis for assessing the cost-benefit associated with personnel selection and training interventions that follow.

##### **5.2.4.1 Response**

We concur that the greatest operability challenges to operators occur in the area of fault, error and critical event handling, as opposed to normal routine operations, however, we have no basis for identifying the frequency of occurrence nor severity of such problems. It would certainly be ideal to quantify the frequency and severity of such problems, were the data on which to base such analyses available. Unfortunately, ECS lacks the operational history required to determine whether problems of this kind really exist, and, if they exist, to quantify their frequency and severity. Likewise, we are unaware of a similar predecessor system that has recorded its own operational history from which we may extrapolate such data. HP OpenView is a mature product, with a long history of usage in operational environments. Certainly such situations are rare, if they occur at all. Consequently, we recommend that the operational history of these sorts of events be tracked during the actual use of HP OpenView (in conjunction with other management system software) in the role for which it was designed. Remedial actions could then be undertaken to redress such problems, if identified at that time.

We feel that the human factors analysis is incomplete, since it does not consider Tivoli TME (a recent addition to the suite of management system software). Tivoli TME provides significant fault, error, and event handling capabilities, and has been selected for implementation with Release A (and beyond). We recommend that Development Engineering/Human Factors Engineering (HFE) conduct a follow-up human factors analysis to address ECS fault, error, and event handling via TME.

We recognize that systems on the scale of ECS have rarely been attempted and therefore take the potential seriously that critical systems events might occur. Towards that end we have taken considerable effort to design and implement a comprehensive critical event and error handling system that relies on the use of a centralized event management platform (workstation) for critical event management. Detailed designs of an ECS event and error handling system have been developed, including the preparation of human factors guidelines for critical event management and operator response, as identified in the internal ECS references shown below:

- a. Event handling: preliminary design and implementation instructions for ECS software designers and developers; draft (November 9, 1995)
- b. Error handling: preliminary design and implementation instructions for ECS software designers and developers; draft (October 25, 1995)
- c. Human factors guidelines for critical event management and operator response; Draft (March 1, 1995)

Release A is implementing these design concepts into a basic capability that relies on HP OpenView and Tivoli TME, as well as on an event and error reporting and logging infrastructure common to all Release A custom components. A systematic event logging, filtering, and priority setting capability is under development and will complete the Release A capability to respond to critical events. Release B plans to extend this basic Release A capability during its normal development schedule and is examining the Release A design documents (cited above) on which it is based. The operational history data that were briefly mentioned in a prior paragraph, will be particularly useful in defining performance parameters and critical event precursors that can be operationalized within Tivoli. These data will greatly enhance the monitoring, detection, and event identification capabilities contained within the ECS management system.

The combination of these efforts should mitigate many of the concerns regarding system operability during critical unplanned events. Clearly, the capability to manage and respond to critical events will be enhanced as ECS scales upward toward full implementation.

### **5.2.5 Recommendation #5: Personnel Selection/Job Definition: AutoSys/Xpert**

Recommend the development and adoption of personnel selection/job definition policies that require demonstrated fault management aptitude (per section 4.2, Establishment of Certification Requirements, contained in the Training Plan for the ECS Project, 622-CD-001-001).

#### **5.2.5.1 Response**

Based on our responses to Recommendations #1 and #3, we do not see the need for special certification requirements for operators involved in data processing using AutoSys/AutoXpert. Certification tasks for operating the complete data processing system should be adequate to meet this need. There are two types of tasks, both routine operations, related to fault/error events involving AutoSys/AutoXpert that are candidate tasks for certification. The first is operator response to the failure of a PGE to complete processing as prescribed. The second is operator response to an AutoSys/AutoXpert software error. We will address the need to list these two types of tasks as certification tasks when preparing the M&O certification plan in response to DID 626.

### **5.2.6 Recommendation #6: Personnel Selection/Job Definition: HP OpenView**

Recommend the development and adoption of personnel selection/job definition policies that require demonstrated fault management aptitude (per section 4.2, Establishment of Certification Requirements, contained in the Training Plan for the ECS Project, 622-CD-001-001).

#### **5.2.6.1 Response**

We concur with the recommendation to identify critical system fault/error management tasks for which operators should be certified. This analysis will be conducted as part of the effort to prepare the M&O certification plan in response to DID 626. The analysis will be conducted per

section 3.3.1 of the *Training plan for the ECS project*, (622-CD-001-002; dated 11/95). Certification testing on such tasks will also be prepared and exercised in accordance with the concepts presented in the training plan. This will ensure that operators possess the skills, knowledge, and abilities required to respond to critical system faults/errors identified by means of the software tools provided by the management system (MSS).

## 5.2.7 Recommendation #7: Training and Job Aid Development: AutoSys/Xpert

Develop fault management training and exercises designed to instruct operators on fault management operations associated with data processing failures/errors (especially for common cause and common mode failures) (per section 4.2, Establishment of Certification Requirements, contained in the Training Plan for the ECS Project, 622-CD-001-001).

### 5.2.7.1 Response

Based on our responses to Recommendations #1 and #3, we do not see the need for enhancing the training objectives for data processing, involving AutoSys/AutoXpert, beyond that required to afford adequate coverage to the complete data processing system. This means that, we believe that AutoSys/AutoXpert will only have responsibility for two types of fault/error events. The first, is operator response to the failure of a PGE to complete processing as prescribed. The second, is operator response to an AutoSys/AutoXpert software error. Consequently, system faults/errors other than these two types will be managed by the management system (MSS).

The current version of the *Training plan for the ECS project* (622-CD-001-002; dated 11/95) contains listings of the tentative training courses planned for development and implementation, that support Release A and B. We will examine the training objectives associated with each of these courses and determine the extent to which training topic coverage supports the training requirements for the types of events listed in the previous paragraph. Table 5-1 presents the list of courses which are planned for development that will support these training requirements. The table identifies whether the course will be developed and implemented for Release A, Release B, or both.

**Table 5-1. Training Courses Related to the Data Processing System**

Training Course	Release A Coverage	Release B Coverage
Data processing system overview	X	X
Planning & Scheduling SW Administration	X (AutoSys/ AutoXpert)	X
Processing CSCI		X

## 5.2.8 Recommendation #8: Training and Job Aid Development: HP OpenView

Develop fault management training and exercises and job aids designed to instruct operators on fault management operations associated with system and network failures/errors (especially for common cause and common mode failures) (per Section 4.2, Establishment of Certification Requirements, contained in the Training Plan for the ECS Project, 622-CD-001-001).

### 5.2.8.1 Response

The current version of the *Training plan for the ECS project* (622-CD-001-002; dated 11/95) contains listings of the tentative training courses planned for development and implementation, for both Release A and B. We will examine the training objectives associated with each of these courses and determine the extent to which training topic coverage supports the training requirements for operator management of critical system events. Table 5-2 presents the list of courses which are planned for development that will support these training requirements. The table identifies whether the course will be developed and implemented for Release A, Release B, or both.

A further task will be to ensure the feasibility of the training required to produce the necessary certified operators, who are expected to be the primary fault management personnel. The training will afford the necessary duration and resources, including exposure to hands-on exercises using realistic fault/error scenarios, to meet requirements. This will ensure that they have the skills and knowledge required to effect an effective fault/error management response to critical system faults/errors.

**Table 5-2. Training Courses Containing Fault/Error Management Concepts and Materials**

Training Course Titles	Release A Coverage	Release B Coverage
MSS overview	X	X
Management SW CSCI		X
Management Agents CSCI		X
Management Logistic CSCI		X
Fault & Performance Management SW Administration	X (Tivoli)	X
Trouble Ticketing SW Administration	X (Remedy)	X
HP OpenView Management	X	X
Lan Analyzer (Sniffer)	X	X
Multiprocessor Maintenance	X (SUN, SGI, or DEC)	X

### **5.2.9 Recommendation #9: Tailor COTS GUIs: AutoSys/Xpert (per Section 3.2); HP OpenView (per section 3.3); Remedy (per section 3.4); Z-Mail (per Section 3.6); All COTS (per Section 3.7)**

Tailor the x-app defaults and user preferences of each COTS product to comply with the human factors guidelines contained in the *ECS User Interface Style Guide* to minimize operator/user performance errors and maximize productivity.

#### **5.2.9.1 Response**

We agree with a goal that all COTS GUIs should comply with the *ECS User Interface Style Guide*. However, the COTS GUIs vary considerably in the degree to which they are customizable to achieve that compliance. Some COTS GUIs, like Remedy (Trouble Ticket), are extremely customizable, due to the availability of a resident GUI builder tool. Other COTS tools are extremely limited in the extent and degree of GUI customization available. We do intend to comply with this recommendation to the extent it is feasible and cost-effective to do so. Therefore, the following actions have been and will continue to be undertaken in our movement towards accomplishing this goal.

- a. Tailor COTS GUIs via x-app defaults to comply with the Style Guide.
- b. Refine COTS GUI customization through consideration of DAAC input via three Release A GUI review workshops (and other DAAC involvement in COTS GUI reviews for Release B).
- c. Continuous involvement with selected COTS vendors to influence GUI modifications for future releases.
- d. Develop workflow analysis models to be reviewed by DAACs at the Release B Ops Workshop; and incorporate feedback into GUI design/customization.
- e. Develop and implement more extensive training and realistic simulations (training exercises based on realistic scenarios) for ECS operators, when practical approaches to reducing the interface complexity of COTS are not feasible.
- f. Identify ECS operator certification tasks for COTS software that are complex and challenging to operators in learning/retaining the skills, knowledge, and abilities necessary for effective operations.

The customization of COTS GUIs is accomplished through the application of a formal process including COTS inspections, DAAC reviews, and human factors engineering assessments to identify areas of improvement that might be addressed through customization of the GUI itself. Further, additional human factors assessments will be made during integration and test to examine the cross-product compatibility of multiple COTS and custom-coded GUIs. This involves observing the use of COTS and custom GUIs to perform operations defined in specific

operations scenarios described in the 605 for Release A and B. The results of these assessments will be used to identify additional changes to COTS and custom GUIs, as well as to identify additional training objectives when GUI modifications are not feasible.

In sum, we see this recommendation as a goal to achieve the effective integration of COTS and custom GUIs. We have defined and implemented a formal GUI development and customization process through which all GUIs--COTS, OTS, and custom software--must proceed. We will ensure compliance with the Style Guide to the extent it is practical and cost effective to do so. Where the underlying complexity of an application(s) cannot be simplified, we will examine training solutions to address the issue.

#### **5.2.10 Recommendation #10: Leverage vendor modifications to COTS GUIs: AutoSys/Xpert (per section 3.2)**

Leverage ECS status as largest customer for AutoSys to encourage Platinum Technology to resolve GUI problems identified in Table 3.2-1.

##### **5.2.10.1 Response**

PDPS developers for Release A and B meet with Platinum Technology on a recurring basis to discuss a variety of concerns that have been identified with AutoSys/Xpert GUIs. We will add the concerns identified by the human factors analysis to our discussions with the vendor to leverage modifications to future releases of Autosys/Xpert.

#### **5.2.11 Recommendation #11: Encapsulate COTS product with custom GUI(s): Sybase**

Develop custom-coded GUIs for all ECS subsystems that require access to the Sybase database engine. Native Sybase user interfaces are non-compliant with the Motif standards and the ECS User Interface Style Guide.

##### **5.2.11.1 Response**

The ECS design architecture forbids any direct end-user interaction with any DBMS, with the narrow exception of data base administration and directly related operations activities (e.g., performance management). All other interactions, including those, for example, of user services, should be mediated through applications (custom or other COTS). Thus, the problem of the Sybase-provided interfaces affects a small community. Recognizing the importance of this whole area, we have recently procured the Enterprise SQL Server Manager (ESSM) from Sybase. ESSM is a COTS product that obtains a full-featured Motif GUI data base administration tool through the Tivoli COTS product, within which ESSM fully integrates. The Tivoli/ESSM combination, providing a Motif GUI, thus removes the import of the character-based interfaces

that were examined by human factors in the report. As to DBMS monitoring, ESSM acts, in principle, as a log event filter for the Sybase RDBMS permitting system monitoring through Tivoli. This reduces dependence on some of the Sybase character-based interfaces even further.

Consequently, ECS operations staff will, in general, use COTS Motif GUIs when performing the required DBA tasks.

In sum, recently available COTS software tools that use Motif GUIs have been selected that are responsive to the requirements of this recommendation. The complete replacement of all non-Motif Sybase tools with a custom "wrapped" GUI for Sybase, as described in this recommendation is now unnecessary.

## 6. Response to Comments

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This section incorporates response to the review comments, including examination of an additional COTS product, *Tivoli*.

One comment noted that the Tivoli Management Environment (TME) has been selected for Release A software failure management, and recommended a follow-up analysis to address ECS fault management via TME. In response to this recommendation, a preliminary examination of TME was conducted. A full analysis was not attempted because the development team had just begun work with the recently installed product and had not yet customized it for ECS. Nevertheless, it was possible to identify projected strengths and weaknesses of TME for ECS use. The TME product appears highly extensible, and its strengths include a wide range of fault/performance thresholds and metrics. Even though it had not been customized for ECS, the look and feel of the TME GUI seemed intuitive. It appeared easy to modify fault/performance parameters. The software provides a capability to define event precursors, a feature that will be useful if and when engineering analysis supports their identification and definition within TME. It provides flexible and responsive support for system-controlled automatic responses to fault events, if the system can provide a capability for such automated responses. Furthermore, it offers flexible and responsive support to operator-mediated responses, which will be useful if and when appropriate operator-mediated responses become known.

The examination of TME revealed some weaknesses. The GUI does not appear to be able to identify or portray defined links or associations between functionally-related events, a capability that will be required for management of common-mode failures. The on-line help is very limited and distinctly substandard. That weakness is particularly important because, in spite of its intuitive GUI and ease of use/modification, TME is a complex program for which the operation will be difficult to master and retain. Finally, although there is a library of fault/performance thresholds and metrics contained in the tool, substantial engineering analyses will be required to develop additional ones. A complete library of thresholds and metrics for ECS may be available only after extrapolation from a long operational history record.

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# Appendix A

## Operator Positions and Responsibilities, and User Characterization

Table A-1 provides a listing of ECS operator positions and responsibilities taken from *Maintenance and Operations Positions' Descriptions*, Document 607-CD-001-002. Table A-2 provides a brief characterization of ECS users and NASA Management roles in ECS.

**Table A-1. Operator Positions and Responsibilities (1 of 6)**

Operator/User	Description/Responsibilities
SMC Accountant	Provide system data collection and reporting; supports each center's accounting/accountability activities. Review and supervise billing activities.
SMC Billing Clerk	Operate billing system to generate and distribute user bills. Receive and processes all payments into billing system, depositing funds into appropriate accounts. Generate periodic and on-demand account verification and financial reports.
SMC System Administrator	System administration and maintenance for all hosts, peripherals, and workstations. Complete initial program loads for all system upgrades. System maintenance and administration, including troubleshooting, preventive, and general system maintenance.
SMC Configuration Management Administrator	Provide CM functions for inter-site network resources. Provide ECS system-wide CM and monitoring, including collecting information describing the state of ECS resources, the network subsystem and its communications resources; exercise control and/or monitoring over the configurations, parameters, and resources of the subsystems and over the information collected; store the configuration information collected and display the configuration information for reporting purposes; assist the SMC personnel in fault, performance, and security management.
SMC Network Analyst	Provide performance monitoring of networks. Support and maintain the high-level network event schedule. Provide reports on all network operations functions.
SMC ECS User Services Working Group (USWG) Liaison	Work with the USWG to provide education information and assistance on the ECS global system, including working directly with the user groups/organizations; help users access the system, describe DAACs' data and services, address or research users' access complaints, work with DAAC User Services to solve systematic user problems; provide feedback to users. Attend Science Team and IWG meetings, learn more about products, keep up on user activities.
SMC/EOC Maintenance Coordinator	Serve as principal COTS HW and SW maintenance resource at the SMC and the EOC. Function as the site's maintenance engineer in cases where a failed component is to be repaired using a self-maintenance approach. Coordinate maintenance actions in which maintenance support from a contracted maintenance vendor or the OEM is used. Interface with the Management Subsystem (MSS) for recording and monitoring maintenance actions.
SMC Computer Operator	Operate SMC host processors, supporting restarts, reboots, and shutdowns. Monitor system status and respond to console messages, documenting all operations activity. Basic system maintenance and administration, and the direction of the system administration and engineering staff, including troubleshooting, preventive, and general system maintenance.
SMC Fault Manager	Provide focal point for inter-ECS center problems; perform fault analyses including isolation, location, identification, and characterization. Responsible for interacting with external systems regarding inter-system problems. Support fault diagnosis testing for hardware, software, and resource-to-resource connectivity. Support other centers' fault management activities.

**Table A-1. Operator Positions and Responsibilities (2 of 6)**

<b>Operator/User</b>	<b>Description/Responsibilities</b>
SMC Operations Supervisor	Responsible for the performance of all SMC "on-line" operations personnel and resources in accordance with approved SMC and company policies, plans, procedures, schedules, and priorities. Provide direction and assistance to "on-line" operations staff as needed. Provide reports to management as required. Responsible for overall performance and utilization of both operations staff and resources. Serve as focal point for all operations-related problems and assign and prioritize all problem investigation and resolution activities in consultation with management.
SMC Performance Analyst	Maintain and modify hardware characteristics database; generate monthly, weekly, and daily hardware activity schedules; monitor system anomaly tracking and analysis. Monitor, analyze, trend, and report local system performance; recommend and track implementation of changes to system control parameters to improve system performance; monitor overall ECS system-wide performance. Alert DAAC personnel to potential performance issues and problems and SMC, ECS M&O Office and/or Project Management to circumstances that may require coordination between DAACs with Project (ESDIS) participation.
SMC Resource Controller	Responsible for all SMC hardware utilization, performance, and configuration. Develop plans and coordinate scheduling for system-wide events and activities. Provide impact assessment for SMC and system-wide configuration changes. Provide on-line leadership, direction, and coordination to DAAC Resource Managers for ECS system-level resource problem resolution, priorities, and configuration.
SMC Security Controller	Support management's development of ECS system-level and SMC-specific operations security policies for the protection of facilities, personnel, equipment, communications, and data. Coordinate, review, monitor progress, and report sites' implementation of security plans and procedures. Develop, implement, and report progress for SMC-specific implementation. Identify security training and awareness education requirements; monitor and report progress on site-specific implementation. Coordinate with Building 32 physical security force (GFE) the EOC, SMC, GSFC DAAC planning and implementation for operations personnel and visitor access control, intrusion protection, badging, and property and information security. Support investigation of potential/actual infractions. Ensure SMC and system-wide awareness and adherence to government and company personnel health and safety policies, practices, and procedures. Maintains security documentation. Monitors, audits, and reports security adherence. Manages SMC system-level security databases. Monitors, investigates, and reports on SMC and system-wide security alarms/notifications.
DAAC Administrative Assistant	Perform secretarial and administrative functions for all DAAC ECS personnel and administer the DAAC ECS technical library. This position includes providing typing support, filing, processing expense reports, performing administrative functions, preparing travel arrangements, and maintaining the DAAC ECS Technical Library (both database listing and technical documents).
DAAC Archive Manager	Monitor the data archive to ensure that it is properly logged into and out of the ECS system. Maintain the catalog of data and monitors distribution of data that is made available for use by science users and operations community on demand. Ensure the viability and safety of storage media and replace and repair media as necessary.
DAAC System Administrator	System administration and maintenance for all hosts, peripherals, and workstations. Complete initial program loads for all system upgrades. System maintenance and administration, including troubleshooting, preventive, and general system maintenance.

**Table A-1. Operator Positions and Responsibilities (3 of 6)**

Operator/User	Description/Responsibilities
DAAC SE - Configuration Management Administrator	Coordinate usage of approved configuration management procedures with elements and external interface configuration management. Maintain control of all DAAC configured hardware, software, science software and specified DAAC documents. Ensure that changes to the hardware, software, and procedures are properly documented and coordinated. Coordinate usage of approved configuration management procedures with elements and external interface configuration management. Assist in the development and administration of the library with respect to configuration management procedures. Provide recording tasks for DAAC CCB, generates configuration and problem status reports and prepares agendas for and schedules CCB meetings.
DAAC Data Base Administrator	Maintain the data bases and structure management for the integrated SDPS and system management functions. Perform the data base administration utilities, such as data base backup and recovery, performance monitoring and tuning. Administer user access control (ACLs), and daily data base synchronization.
DAAC ECS Contractor Manager	Responsible to the DAAC Manager and Scientist for contractor/sub-contractor ECS system operation and maintenance. Organize and manage M&O staffing, training, procedures, and performance reporting to plan and execute operations and maintenance in accordance with DAAC Management objectives, priorities, and policies.
DAAC Maintenance Coordinator	Serve as principal COTS HW and SW maintenance resource at the DAAC. Function as the site's maintenance engineer in cases where a failed component is to be repaired using a self-maintenance approach. Coordinate maintenance actions in which maintenance support from a contracted maintenance vendor or the original equipment manufacturer (OEM) is used. Interface with the Management Subsystem (MSS) for recording and monitoring maintenance actions.
DAAC Integrated Logistics Support (ILS) Administrator	Provide control of contractor and government ECS property at the DAAC and maintain a continuous audit trail from receipt of a COTS item until transfer of accountability. Maintain accountability for all ECS equipment at the DAAC until accepted by CO/COTR, and for all equipment for which the contractor has M&O responsibility.
DAAC Science Coordinator	Responsible to DAAC Manager/Scientist for science software integration, operational quality assurance of the science products and for services to the DAAC's users. Interface with the DAAC Scientist, Instrument Teams, ECS Science Office, and DAAC user community to define the DAAC's science operations objectives, priorities, performance metrics/satisfaction criteria, and performance reporting.
DAAC Science Software I&T Support Engineer	Provide DAAC SSI&T execution support, ECS tool and system expertise and science S/W processing problem support. Provide support to scientists in the development and integration of science software for both updates and new science software into the DAAC ECS system. Provide support to Instrument Teams for development and integration of science software into the DAAC ECS system. Support science processing problem investigation and resolution. Recommend, assess, develop, and implement changes to science toolkit software. Assess impacts and support integration and test for production planning and processing software changes.
DAAC Software (S/W) Maintenance Engineer	Provide/support site problem resolution, integration and test of system changes and develops DAAC-unique extensions to ECS software. Produce, deliver and document the corrections, modifications, and enhancements made to ECS soft-ware (including COTS), and/or adapt or incorporate COTS software for ECS use.
DAAC System Engineer	Analyze and support problem resolution and engineering change activities, including all ECS interfaces; analyze and identify ways to accommodate needed improvements, new technologies and new concepts; plan and manage system upgrades and evolution; control and maintain ECS updates and perform the activities necessary to assure ECS reliability, maintainability, and availability. Work with Technical Advisory Group (TAG) to evaluate user inputs and monitor system performance to tune the system for optimum response and support.

**Table A-1. Operator Positions and Responsibilities (4 of 6)**

Operator/User	Description/Responsibilities
DAAC SE System Test Engineer	Provide plans, configurations, and procedures for software upgrades and training procedures to be tested and implemented at the DAAC. Execute formal and impromptu testing at the DAAC, reporting and analyzing findings.
DAAC User Services Representative	Provide services and expertise necessary to facilitate access to and use of EOSDIS-related systems, data, software, tools, services, and products by the user community (via e-mail, fax, mail, Internet and WWW tools, telephone, or face-to-face contact). Assist with the data ingest/QA/advertising efforts of the DAAC, and provide local DAAC Management with routine and on-demand reports on various User Services-related topics.
DAAC Science Data Specialist	Provide technical support to DAAC, including its user services personnel. Answer detailed questions concerning the structure of the discipline data stored at the DAAC; serve as the DAAC interface to the Instrument Teams for SSI&T, problem resolution, and DAAC operations quality assurance analysis. Provide technical support to the DAAC User Services Representative. Provide on-site expertise on the development and use of data and metadata, subsets of data, numerical methods and tools, vector and parallel processing techniques, visualization and graphics tools, analysis tools, expert systems, data formats and computing techniques. Support initialization and maintenance of data server and production planning databases, develop advertisements for new datasets and services, and work with the Database Administrator in structuring databases, datasets and metadata.
DAAC Computer Operator	Operate DAAC host processors including restarts, reboots, and shutdowns. Monitor system status and respond to console messages, documenting all operations activity. Basic system maintenance and administration, at the direction of the system administration and engineering staff, including troubleshooting, preventive, and general system maintenance.
DAAC Ingest - Distribution Technician	Receive, log, and mark all non-electronic media for processing and storage in the ECS system. Return original media to sender, and/or file and store it. Coordinate with sender to resolve any ingest problems and receive, open, and route incoming mail to appropriate action department. Package, label, and ship output to science users, and follow up and trace undelivered output. Control the flow of DAAC input and output by managing the ingest and distribution process queues. Assist DAAC Archive Manager in monitoring the performance of the ingest, archival, and distribution function from a workstation console using both ingest and data server subsystem supplied graphical user interface (GUI) tools.
DAAC Operational Readiness and Performance Assurance Analyst	Ensure DAAC staff, hardware, software, documents, and databases are in a state of operational readiness at all times, including requisite DAAC system changes and launch preparations. Monitor M&O activities, providing visibility to DAAC management. Plan, verify, and report operational readiness activities including witnessing system tests, coordinating training exercises, and operator certification. Provide coverage of operational phase activities in PAIP (DID 501/PA1). Continue the tasks of the RMA program throughout the operational phase.
DAAC Operations Supervisor	Ensure all operations staff adhere to established policies, procedures, and schedules. Provide direction and assistance to "on-line" staff as needed. Provide reports to management as required. Responsible for overall performance and utilization of both operations staff and resources. Serve as the focal point for all operations-related problems and assign and prioritize all problem investigation and resolution activities in consultation with management.
DAAC Production Monitor	Monitors science software execution via automated tools. Manage On-Demand and planned processing schedules and requests, document and support problem resolution, and report performance status.
DAAC Production Planner	Develop daily, weekly, and monthly DAAC science production schedules. Populate and maintain production database with science software characteristics, production rules, and priorities. Develop and maintain ancillary/input data schedules.

**Table A-1. Operator Positions and Responsibilities (5 of 6)**

<b>Operator/User</b>	<b>Description/Responsibilities</b>
DAAC Resource Manager	Coordinate with SMC for network problems and DAAC reconfigurations in response to ECS system anomalies. Responsible for site hardware, software, LAN, and local DCE cell configuration, allocation, and utilization performance in accordance with site and system approved resource baselines and schedules. Document and oversee investigations of hardware, software, and LAN efforts/faults.
DAAC Resource Planner	Responsible for reviewing and integrating all resource requests for DAAC system resources into daily, weekly, and monthly DAAC resource schedules. Conduct DAAC Resource scheduling meetings for DAAC management review and approval of resource schedules.
ECS M&O Office Manager	Responsible for the personnel, technical, and financial performance of all ECS M&O activities. Report to the ECS Program Manager and provide programmatic supervision of all ECS M&O organizations. Provide personnel supervision (in concert with or through ECS subcontractors) of all ECS personnel.
ECS SEO Manager	Overall responsibility for the performance of all SEO personnel, housed at GSFC Building 32, to provide a system-wide M&O function that is responsive to the ESDIS Project Office and the Project Scientist. Provide a system perspective on maintenance, sustaining engineering, and training. Integrate efforts of other M&O organizations to provide a focus for development organization interactions and assuring that ECS Science goals are met.
SEO Administrative Assistant	Perform secretarial and administrative functions for all SEO and ILS ECS personnel. This includes providing typing support, filing, processing expense reports, performing administrative functions, and preparing travel arrangements.
SEO System Administrator	Administer and maintain all SEO office and operations support computer hosts, peripherals, and workstations, including troubleshooting, preventive and general system maintenance. Complete initial program loads for all system upgrades. Provide configuration, security, and access administration.
SEO Configuration Management Administrator	Coordinate usage of approved configuration management procedures with elements and external interface configuration management. Ensure that changes to the hardware, software, and procedures are properly documented and coordinated. Maintain control of all configured hardware and software. Assist in the development and administration of the library with respect to configuration management procedures. Provide recording secretarial tasks for ESDIS CCB (if requested by ESDIS CCB). Coordinate RID requests generated during M&O reviews. Generate CCB monthly reports. Prepare agendas for and schedule CCB meetings.
SEO Librarian	Maintain the ECS system-level technical library. Serve as the Database Administrator for the Document Data Server Subsystem which is used to manage documents related to the operational baseline, including system requirements, design, interfaces, and baselined operations plans. Enter baselined ECS documents into the Document Data Server and control them at site and system level, using word processors. Process change packages to the user community; maintain and update the controlled master (gold) copy of all documents. Maintain document inventory and links to the ECS Configuration Items in the Baseline Manager tool (XRP-II), with support and coordination of the SMC Configuration Management Administrator.
SEO Operations Readiness & Performance Assurance Analyst	Generate and maintain Operational Readiness Plan (DID 603/OP1) and update prior to each RRR. Ensure system is in a state of operational readiness at all times including launch preparations. Conduct Segment Operational Readiness Reviews (SORRs) and the regular monitoring of M&O activities, providing visibility to both the CE/COTR and program management. Provide coverage of operational phase activities in PAIP (DID 501/PA1). Continue the tasks of the RMA program throughout the operational phase. Coordinate with DAAC, SMC, and EOC personnel responsible for Operations Readiness. Coordinate the resolution of Trouble Tickets, support for overall Trouble Ticket System, and administrative support of the Trouble Ticket Review Board.

**Table A-1. Operator Positions and Responsibilities (6 of 6)**

<b>Operator/User</b>	<b>Description/Responsibilities</b>
SEO ECS Operations Trainer	Manage the ECS M&O training program. This includes planning, scheduling, and conducting all ECS training courses, developing course curriculum to support the training courses, supervising the training staff, coordinating all training activities with the FOT, DAAC, and SMC training management, developing and maintaining the certification skills plan, and managing the COTS training program. Coordinate implementation of ongoing training and certification through each site's Operational Readiness and Performance Assurance Analyst (ORPA).
SEO Science Coordinator	Responsible to ESDIS Management/Project Scientist for planning ECS system integration of science software, operational quality of the ECS science products and for services to the ECS users. Interface with the Project Scientist, Instrument Teams, ECS Science Office, DAAC Science Coordinators, and ECS user organization to define the ECS science operation objectives, priorities, performance metrics/satisfaction criteria, and performance reporting.
SEO Software (S/W) Maintenance Engineer	Produce, deliver, and document the corrections, modifications, and enhancements to ECS software (including COTS) and/or adapt or incorporate COTS software for ECS use.
SEO System Engineer	Analyze and identify ways to accommodate needed improvements, new technologies, and new concepts; manage system upgrades and evolution; control and maintain ECS updates, and perform the activities necessary to assure ECS reliability, maintainability, and availability. Work with the Technical Assistance Group (TAG) to evaluate user inputs and monitor system performance to tune the system for optimum response and support.
SEO System Test Engineer	Provide plans, configurations, and procedures for software upgrades and training procedures to be tested and implemented at the SEO. Execute formal and impromptu testing of software at the SEO; analyze and report findings.
ECS Integrated Logistics Support (ILS) Contractor Manager	System-wide responsibility for the management of logistics operations in support of ECS objectives and the science support missions. Provide a systems perspective on logistics support operations and on the installation, maintenance, and training of commercial off-the-shelf (COTS) hardware and software. Plan and manage ECS logistics operations under the general direction of the M&O Manager. Provide logistics interface with the ECS development organizations; this includes logistics issues related to design supportability, design tradeoffs, and system upgrades.
ILS Administrator	Provide control of contractor and government ECS property at the SEO, the SMC, and the EOC, and maintain a continuous audit trail from receipt of a COTS item until transfer of accountability. Maintain accountability for all ECS equipment at these sites until it is accepted by CO/COTR, and for all equipment for which the contractor has M&O responsibility.
ILS Logistics Engineer	Serve as system-level logistics monitor and coordinator. Perform system-level coordination, scheduling, monitoring, planning, reporting, spares/repair parts and consumables planning, and vendor contracting of ECS logistics support.
Installations Coordinator	Plan, coordinate, and monitor all installations of ECS equipment at ECS sites.
ECS Property Administrator	Maintain accountability of all government-procured property in the ECS system.

**Table A-2. User and NASA Management Roles**

<b>Operator/User</b>	<b>Description/Responsibilities</b>
Science Users	Investigators funded by NASA under the EOS program, including all Principal Investigators, Team members of all of the Interdisciplinary Science Investigations, and all Instrument Investigators and Team members. General Science Users (e.g., other members of relevant Professional Societies actively engaged in related research; Atmosphere, Ocean, and Earth Science faculty members in graduate programs and their graduate students)
Non-Science Users	Users from Federal and State agencies who are not doing scientific research; K - 12 students and teachers; commercial users; intermediaries; library users; service providers
NASA Management	Program oversight

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## Appendix B

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### Software Products/Functions

**Table B-1. Software Products and Functions for ECS (1 of 2)**

Environment	Software	Function
COTS/OTS	OpenView	System Monitoring/Control
	Remedy	Troubleshooting
	SYBASE	Data Base Engine
	Illustra	Data Base Management
	Clearcase	Configuration Management
	Distributed Defect Tracking System (DDTS)	Change Request Management
	Physical Network Manager	Physical Configuration Management
	XRP II	Baseline Manager
	HAL	DCE Cell Management
	Tivoli	Fault/Performance Management
	AutoSys	Scheduling and Operations Automation
	AutoXpert	Scheduling and Operations Monitoring
	Interactive Design Language (IDL)	Visualization/Manipulation of Science Data
	AIT Software Tools	Code Checkers and Software Qualification
	Verity Topic	Free-text indexer and search engine
	Netscape Commerce Server	HTTP Web Server for DDSRV
	Report Generator	Preparation of System Reports
	Statistics and Trend Analysis Tool	System Performance Analysis
	Inventory, Logistics, and Maintenance Tool	Inventory, Logistics, & Maint. Management
	Billing and Accounting System	Billing and Accounting Management
	Z-mail	Electronic Mail
	Netscape, NCSA Mosaic	Web Browsers
		Bulletin Boards
		News Groups
	Common Desktop Environment (CDE)	Desktop
	V0	User Access Interface
	Algorithm Software Tools	Algorithm Development and Support
	Unix	Programming Base
	Unix Scripts	Custom Programmed Functions

**Table B-1. Software Products and Functions for ECS (2 of 2)**

Environment	Software	Function
Custom Motif-Based	Order Tracking Tool	Order Tracking
	Management Subsystem (MSS) - Motif	Management Data Access
	User Profile	User Profile Management
	Ingest Subsystem (INS) - Motif	Data Ingest Functions
	Planning Subsystem (PLS) - Motif	Planning Functions
	Data Processing Subsystem (DPS) - Motif	Data Processing Functions
	Data Server Subsystem (DSS) - Motif	Data Server Functions
	Data Management Subsystem (DMS) - Motif	Data Management Functions
	Client Subsystem (CLS) - Motif	User Access Functions
	Interoperability Subsystem (IOS) - Motif	Interoperability Functions
Custom HTML-Based	Ingest Subsystem (INS) - HTML	Network Ingest Functions
	Data Server Subsystem (DSS) - HTML	
	Data Management Subsystem (DMS) - HTML	
	Client Subsystem (CLS) - HTML	
	Interoperability Subsystem (IOS) - HTML	